US009238790B2

(12) **United States Patent**
Wada

(10) **Patent No.: US 9,238,790 B2**
(45) **Date of Patent: *Jan. 19, 2016**

(54) **INCUBATOR, SCHEDULE MANAGEMENT METHOD, AND PROGRAM**

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(73) Assignee: **NIKON CORPORATION**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 509 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/318,903**

(22) Filed: **Jan. 12, 2009**

(65) **Prior Publication Data**

US 2009/0137030 A1 May 28, 2009

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2008/000349, filed on Feb. 26, 2008.

(30) **Foreign Application Priority Data**

Feb. 28, 2007 (JP) 2007-049023

(51) **Int. Cl.**

C12M 1/34 (2006.01)
C12M 3/00 (2006.01)
C12M 1/00 (2006.01)
C12M 1/36 (2006.01)

(52) **U.S. Cl.**

CPC ***C12M 41/14*** (2013.01); ***C12M 23/50*** (2013.01); ***C12M 41/36*** (2013.01); ***C12M 41/48*** (2013.01)

(58) **Field of Classification Search**

CPC C12M 41/14; B01L 7/00; B01L 7/52; B01L 2300/0829; G01N 21/253; G01N 21/6428; G01N 21/6452; C12Q 1/04

USPC 435/288.7

See application file for complete search history.

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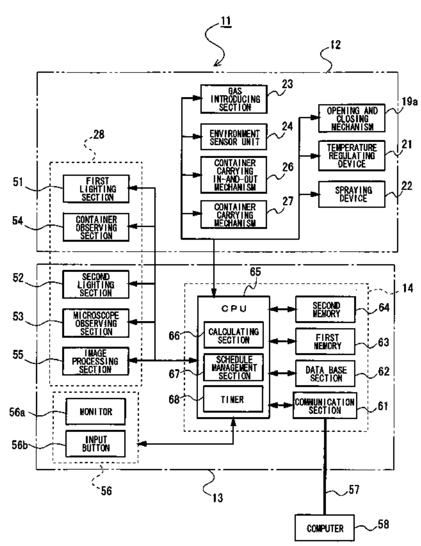
(57) **ABSTRACT**

An input section of an incubator accepts, from a user, a first input selecting a specified incubation container which registers an observing schedule, and a second input specifying an imaging condition of the specified incubation container in an observing sequence. A calculating section calculates, according to the above-mentioned imaging condition, an observing duration of the specified incubation container from a first data relating to a carrying period of an incubation container and a second data with regard to an imaging duration. A schedule management section extracts, based on a schedule data, a registrable time zone in which an observing sequence of the specified incubation container can be executed without overlapping with previously registered observing schedules, and outputs to display the registrable time zone for presentation to the user.

14 Claims, 13 Drawing Sheets



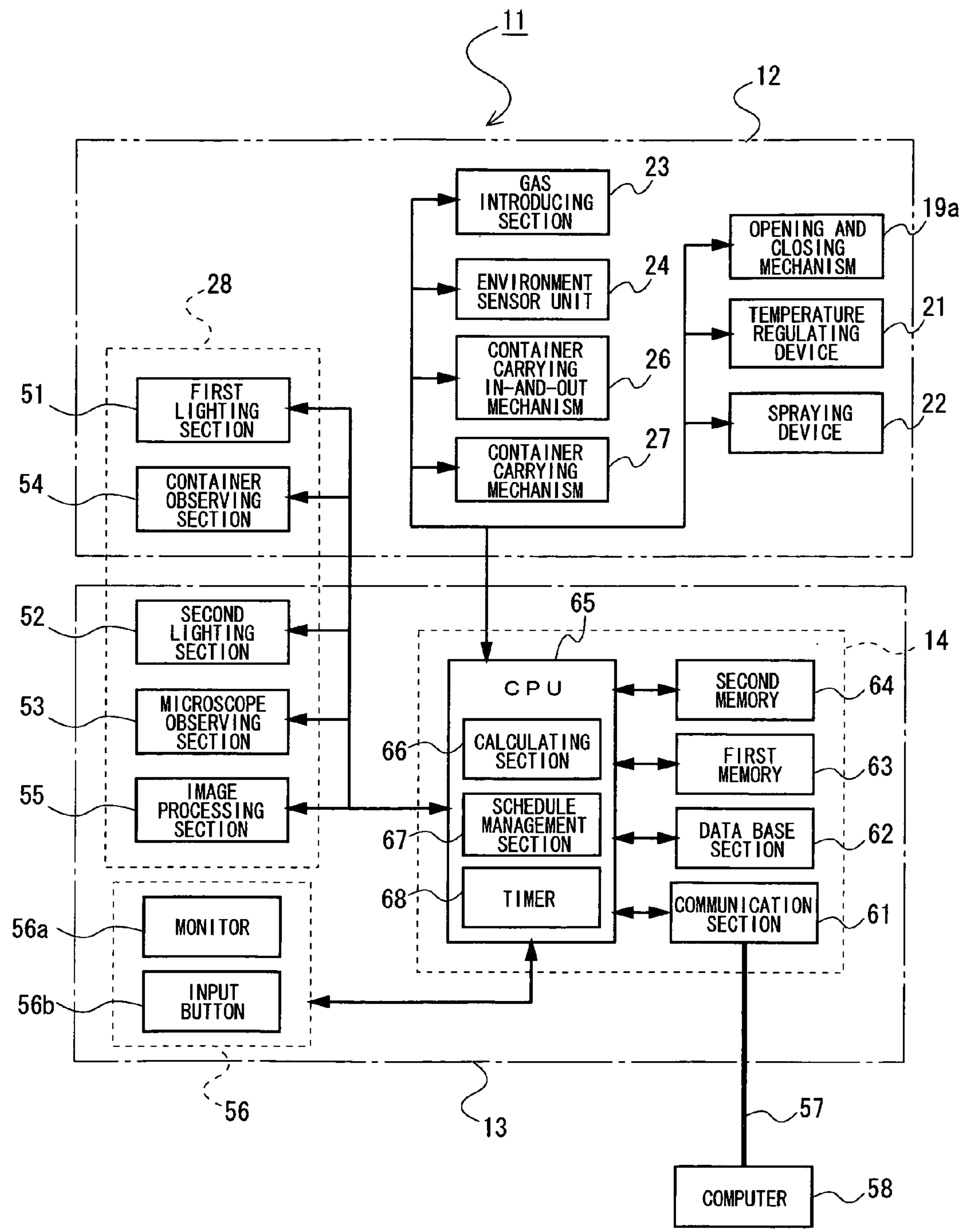

11
12
GAS INTRODUCING SECTION
23
ENVIRONMENT SENSOR UNIT
24
CONTAINER CARRYING IN-AND-OUT MECHANISM
26
CONTAINER CARRYING MECHANISM
27
OPENING AND CLOSING MECHANISM
19a
TEMPERATURE REGULATING DEVICE
21
SPRAYING DEVICE
22
28
51
FIRST LIGHTING SECTION
54
CONTAINER OBSERVING SECTION
52
SECOND LIGHTING SECTION
53
MICROSCOPE OBSERVING SECTION
55
IMAGE PROCESSING SECTION
65
14
CPU
66
CALCULATING SECTION
67
SCHEDULE MANAGEMENT SECTION
68
TIMER
SECOND MEMORY
64
FIRST MEMORY
63
DATA BASE SECTION
62
COMMUNICATION SECTION
61
56a
MONITOR
56b
INPUT BUTTON
56
13
57
COMPUTER
58

FIG. 1

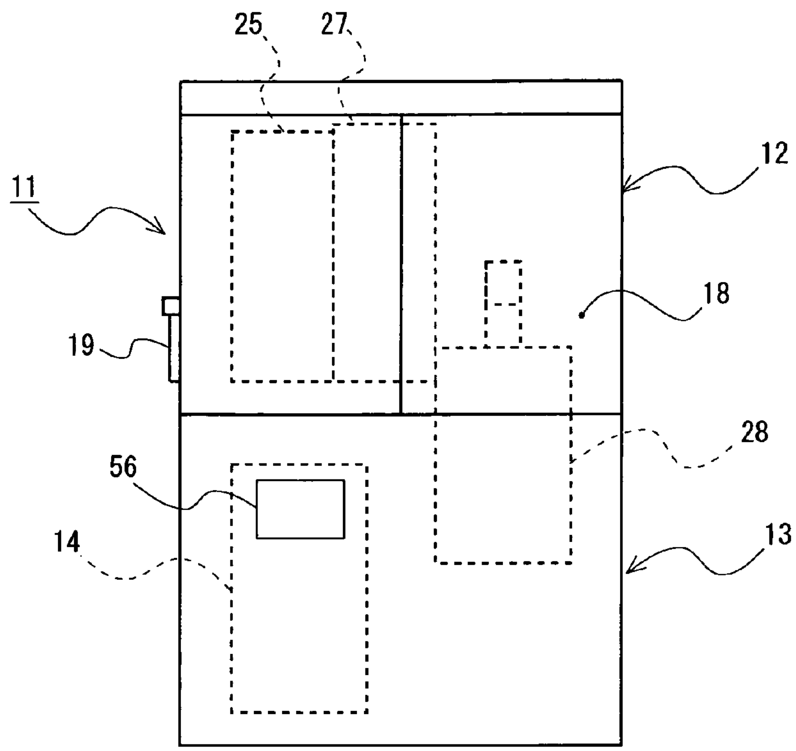

25
27
11
12
18
19
28
56
14
13

FIG. 2

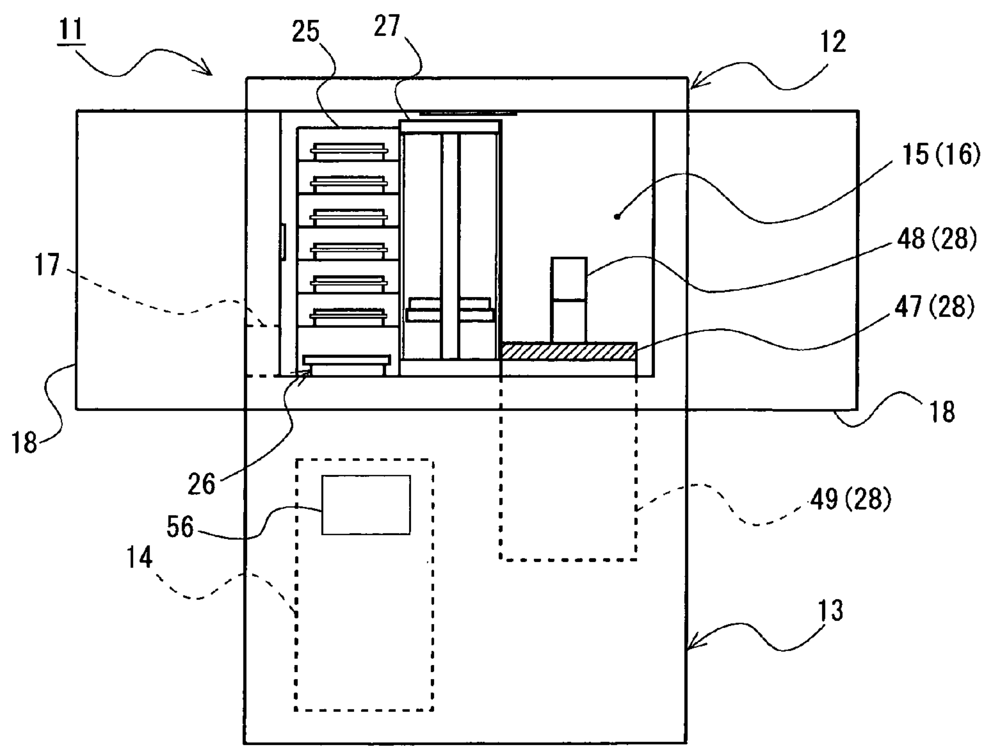

11
25
27
12
15 (16)
48 (28)
47 (28)
17
18
18
26
56
49 (28)
14
13

FIG. 3

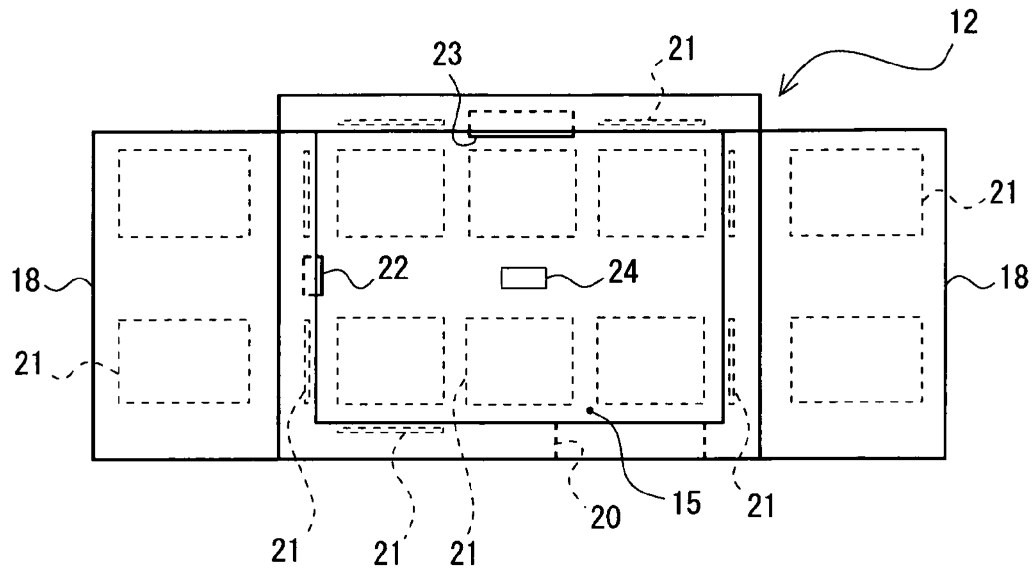

12
23
21
21
18
22
24
18
21
21
21
21
20
15
21

FIG. 4

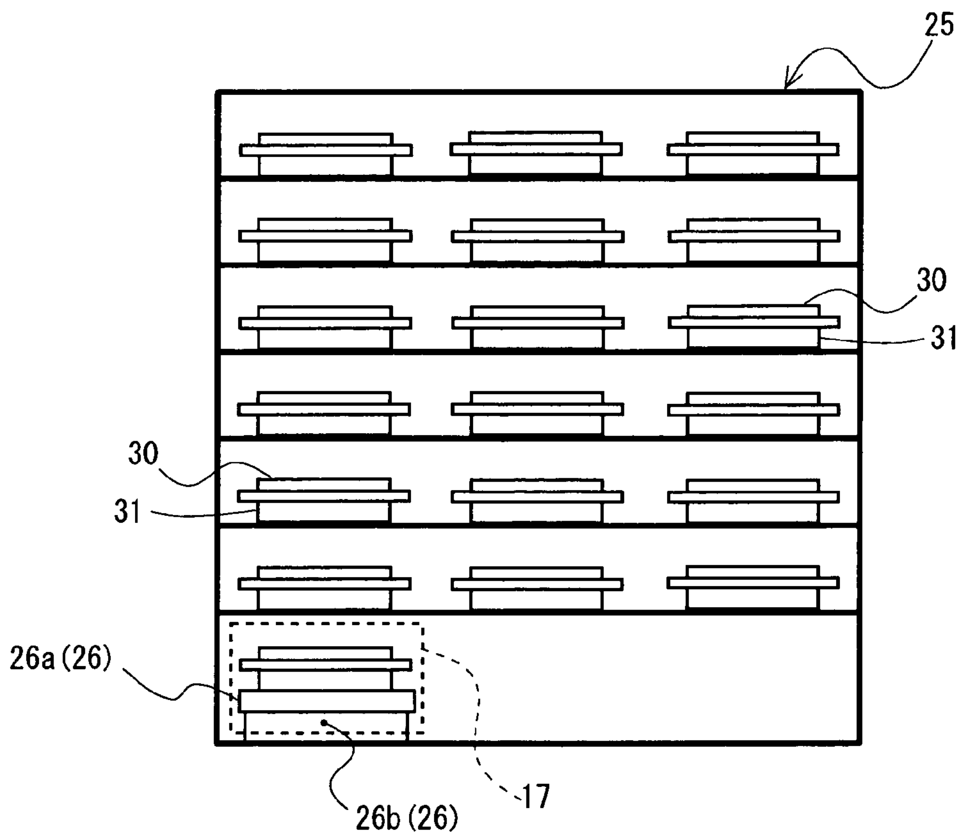

25
30
31
30
31
26a (26)
26b (26)
17

FIG. 5

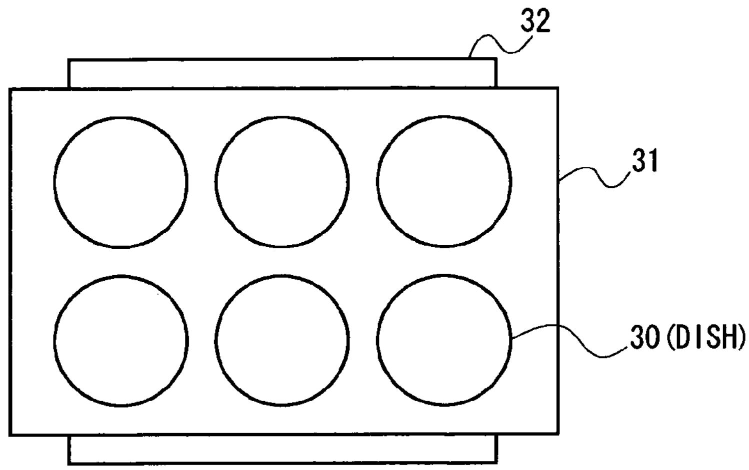


FIG. 6(a)

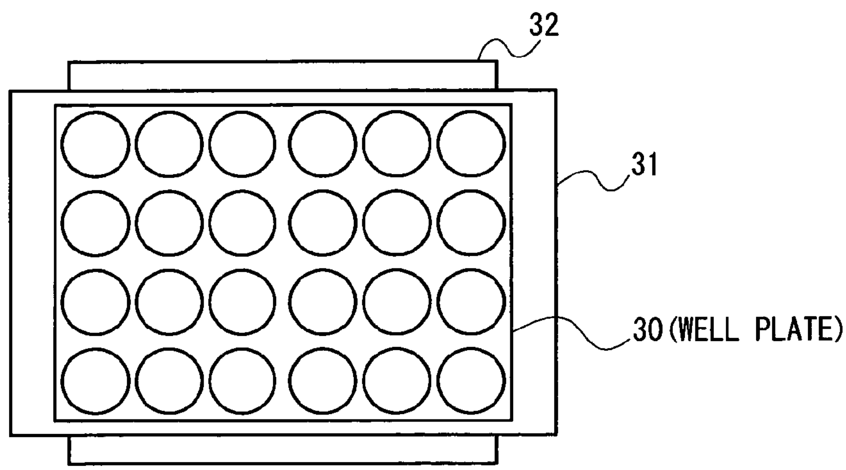


FIG. 6(b)

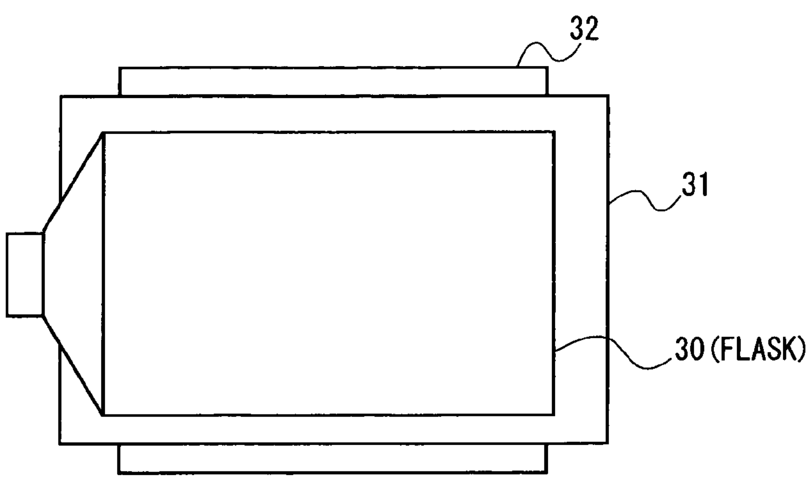


FIG. 6(c)

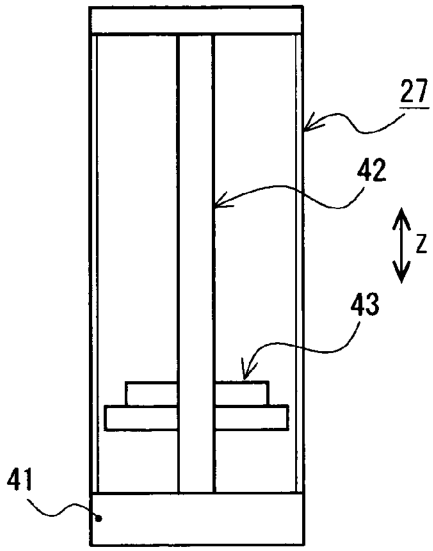


FIG. 7(a)

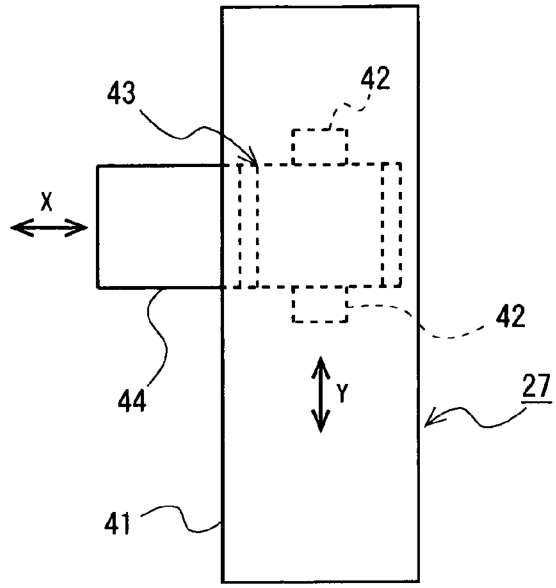


FIG. 7(b)

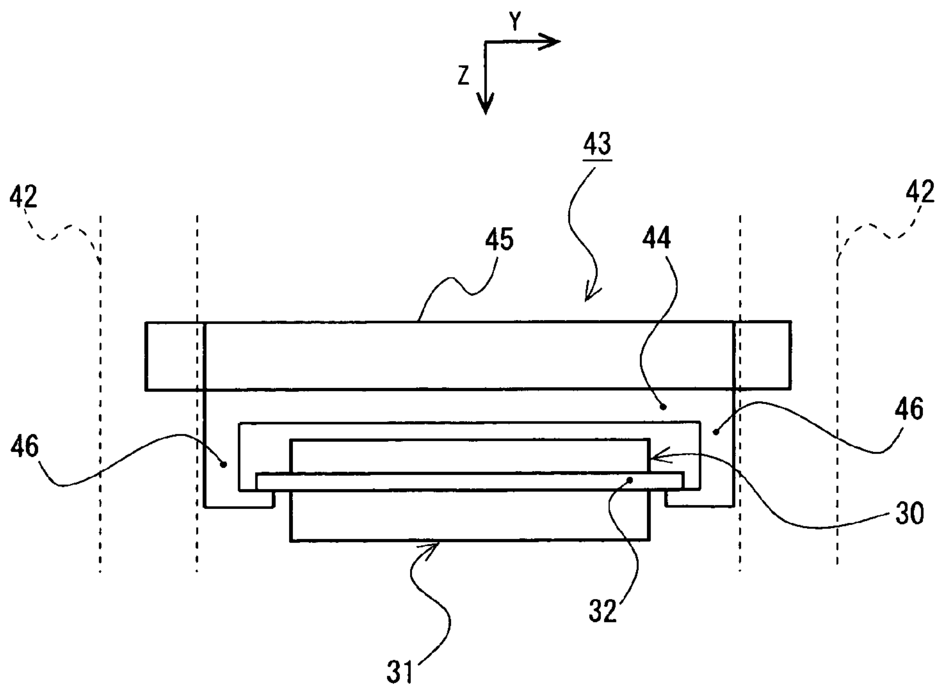


FIG. 8

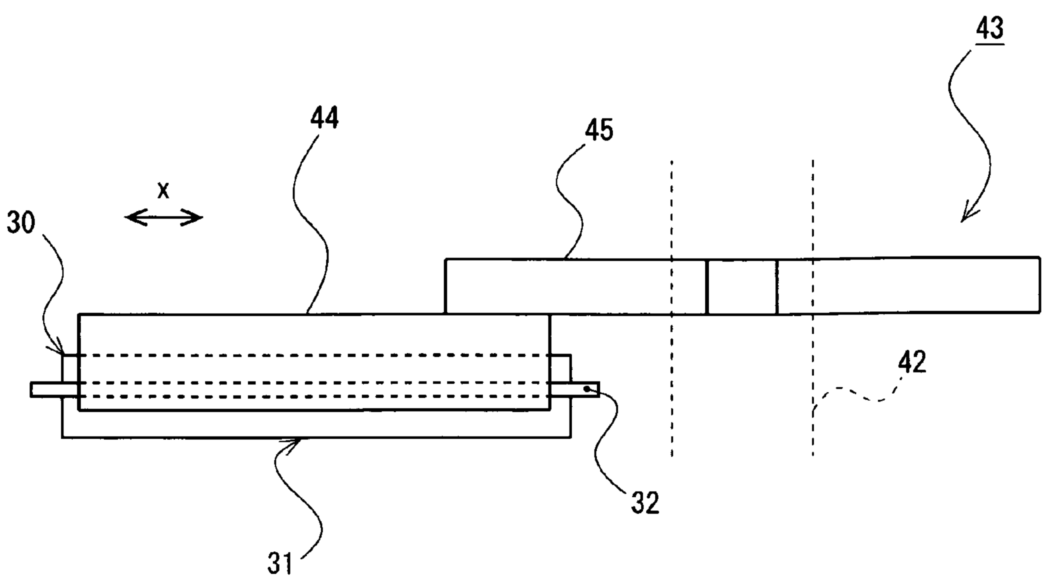


FIG. 9

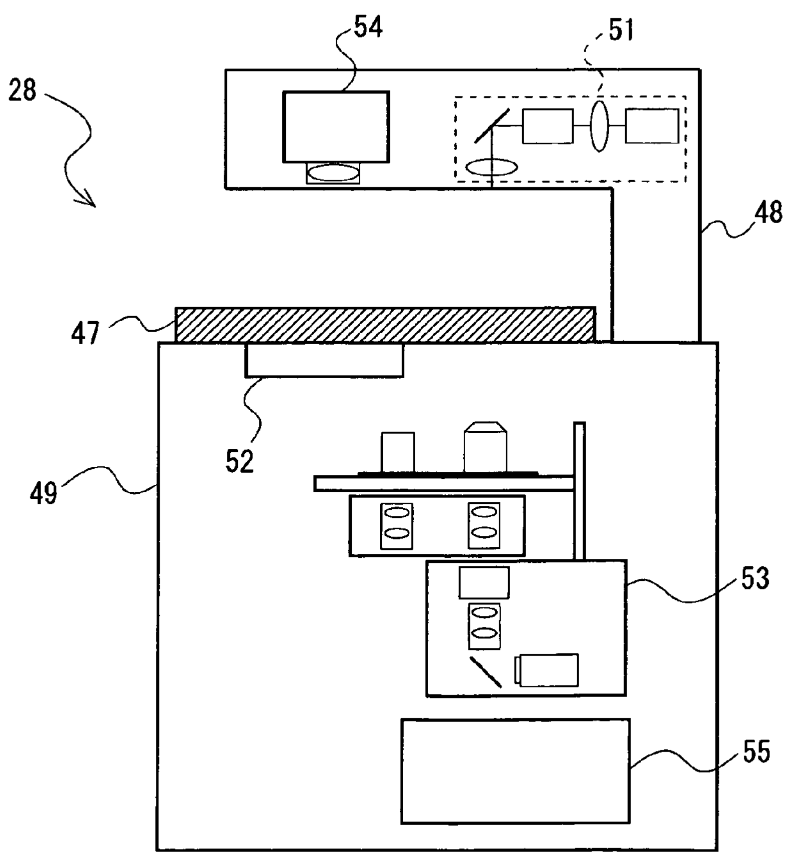


FIG. 10

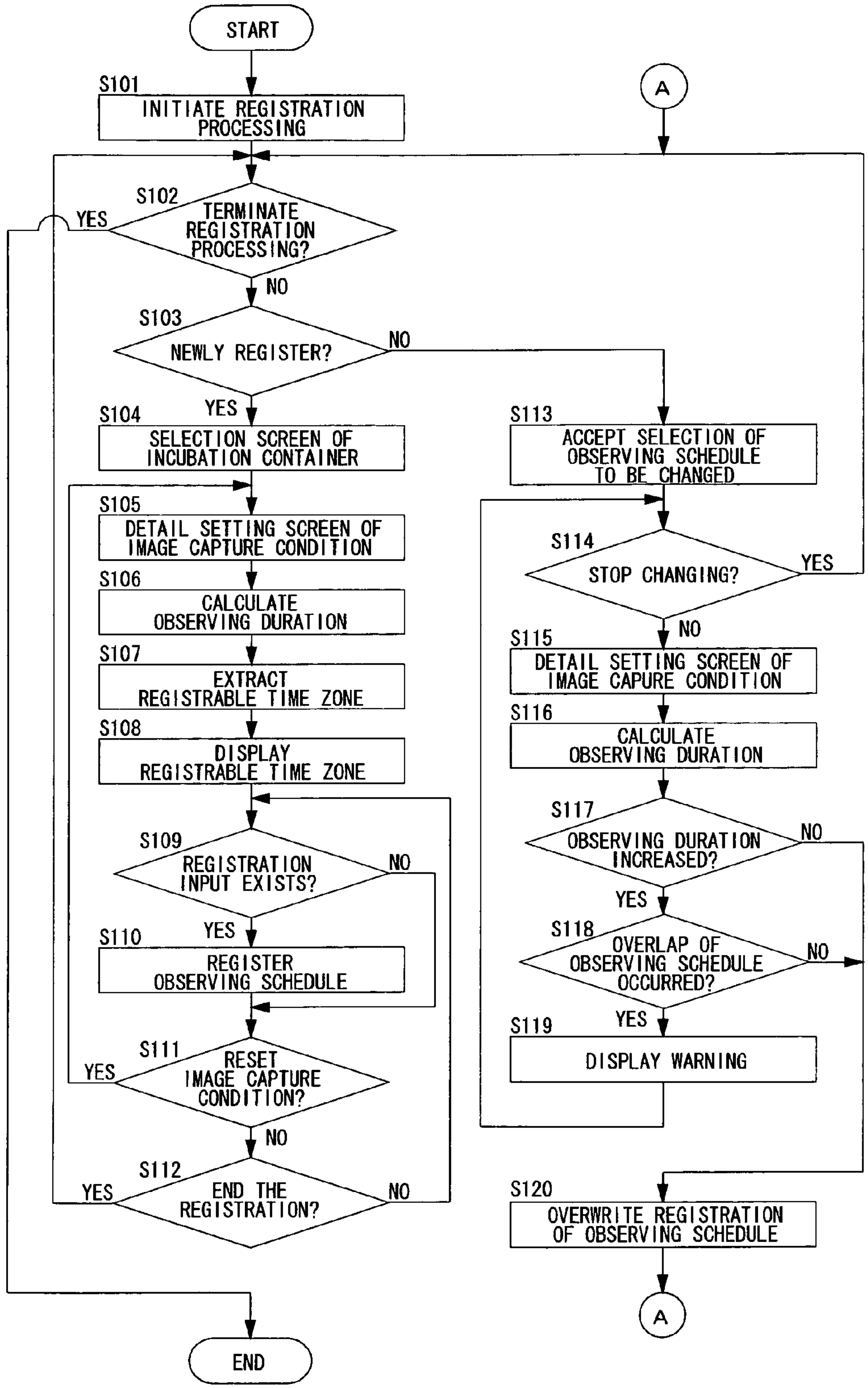

START
S101
INITIATE REGISTRATION PROCESSING
S102
TERMINATE REGISTRATION PROCESSING?
YES
NO
S103
NEWLY REGISTER?
YES
NO
S104
SELECTION SCREEN OF INCUBATION CONTAINER
S105
DETAIL SETTING SCREEN OF IMAGE CAPTURE CONDITION
S106
CALCULATE OBSERVING DURATION
S107
EXTRACT REGISTRABLE TIME ZONE
S108
DISPLAY REGISTRABLE TIME ZONE
S109
REGISTRATION INPUT EXISTS?
NO
YES
S110
REGISTER OBSERVING SCHEDULE
S111
RESET IMAGE CAPTURE CONDITION?
YES
NO
S112
END THE REGISTRATION?
YES
NO
END
A
S113
ACCEPT SELECTION OF OBSERVING SCHEDULE TO BE CHANGED
S114
STOP CHANGING?
YES
NO
S115
DETAIL SETTING SCREEN OF IMAGE CAPURE CONDITION
S116
CALCULATE OBSERVING DURATION
S117
OBSERVING DURATION INCREASED?
NO
YES
S118
OVERLAP OF OBSERVING SCHEDULE OCCURRED?
NO
YES
S119
DISPLAY WARNING
S120
OVERWRITE REGISTRATION OF OBSERVING SCHEDULE
A

FIG. 11

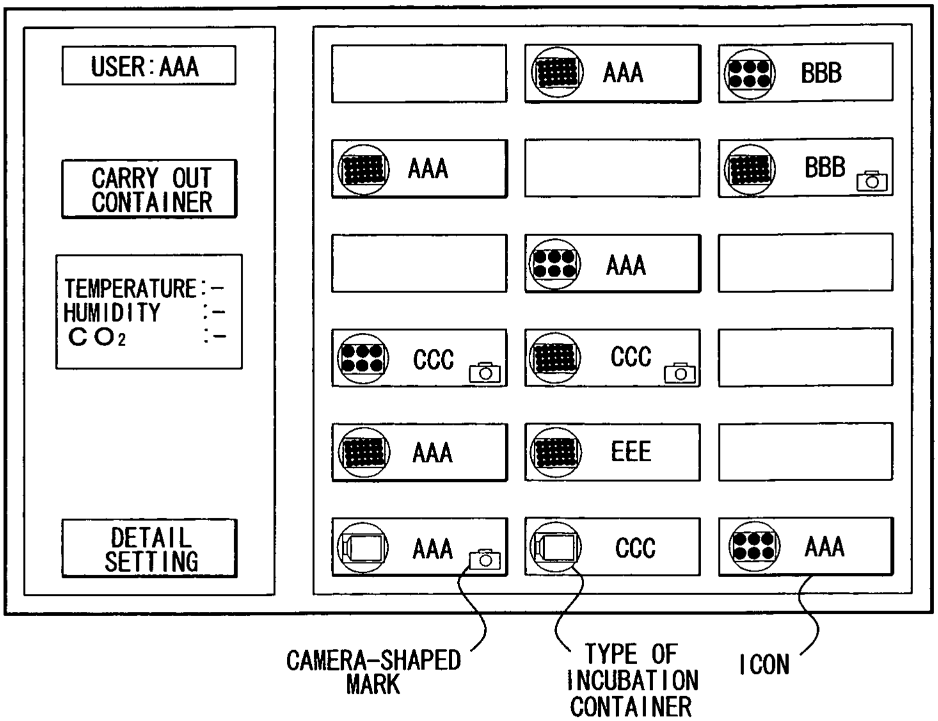

USER:AAA
CARRY OUT CONTAINER
TEMPERATURE:−
HUMIDITY :−
CO2 :−
DETAIL SETTING
AAA
BBB
AAA
BBB
AAA
CCC
CCC
AAA
EEE
AAA
CCC
AAA
CAMERA-SHAPED MARK
TYPE OF INCUBATION CONTAINER
ICON

FIG. 12

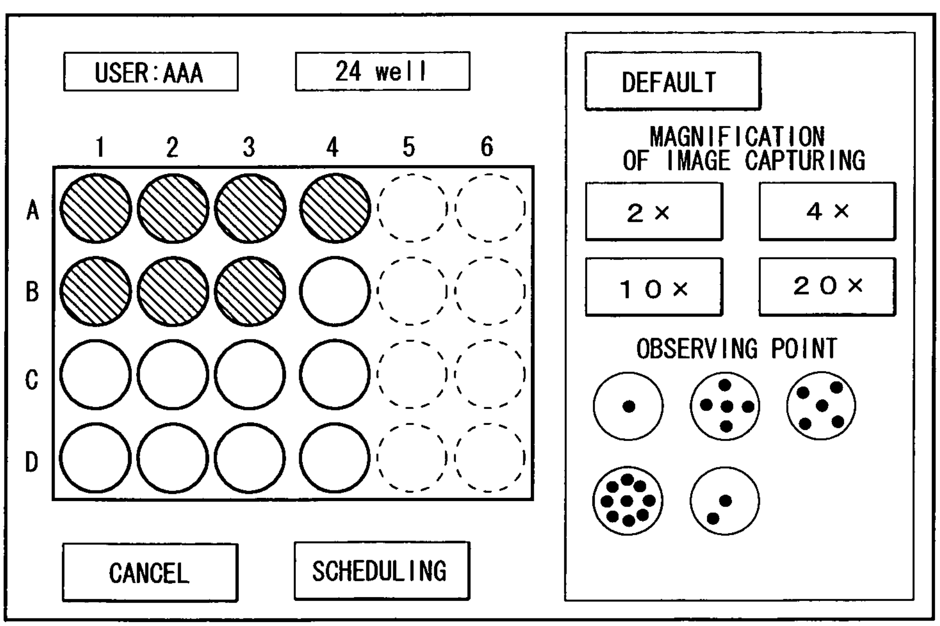

USER:AAA
24 well
1
2
3
4
5
6
A
B
C
D
CANCEL
SCHEDULING
DEFAULT
MAGNIFICATION OF IMAGE CAPTURING
2×
4×
10×
20×
OBSERVING POINT

FIG. 13

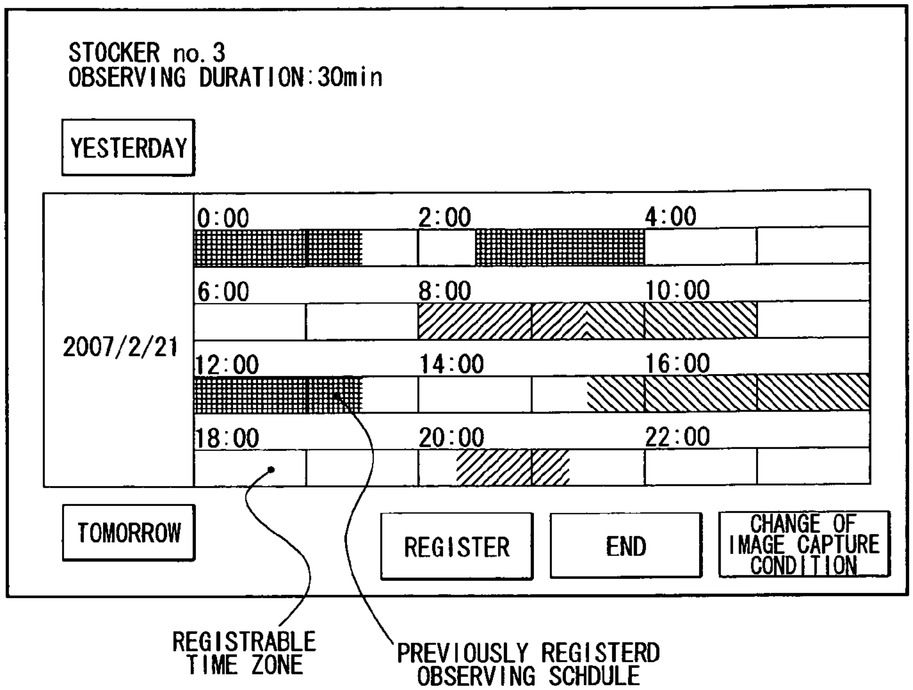

STOCKER no. 3
OBSERVING DURATION:30min
YESTERDAY
2007/2/21
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
TOMORROW
REGISTER
END
CHANGE OF IMAGE CAPTURE CONDITION
REGISTRABLE TIME ZONE
PREVIOUSLY REGISTERD OBSERVING SCHDULE

FIG. 14

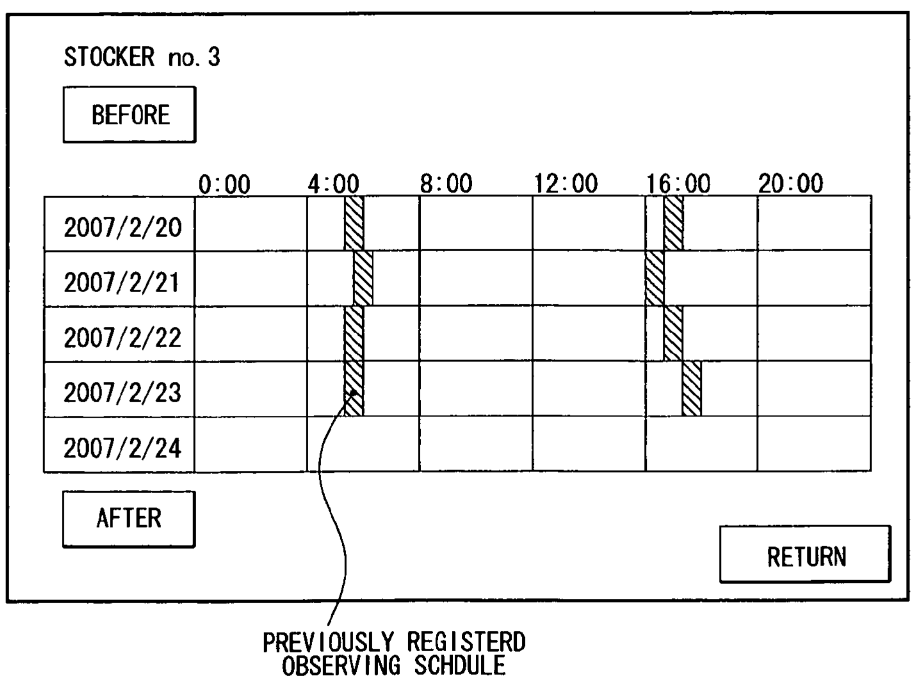

STOCKER no. 3
BEFORE
0:00
4:00
8:00
12:00
16:00
20:00
2007/2/20
2007/2/21
2007/2/22
2007/2/23
2007/2/24
AFTER
RETURN
PREVIOUSLY REGISTERD OBSERVING SCHDULE

FIG. 15

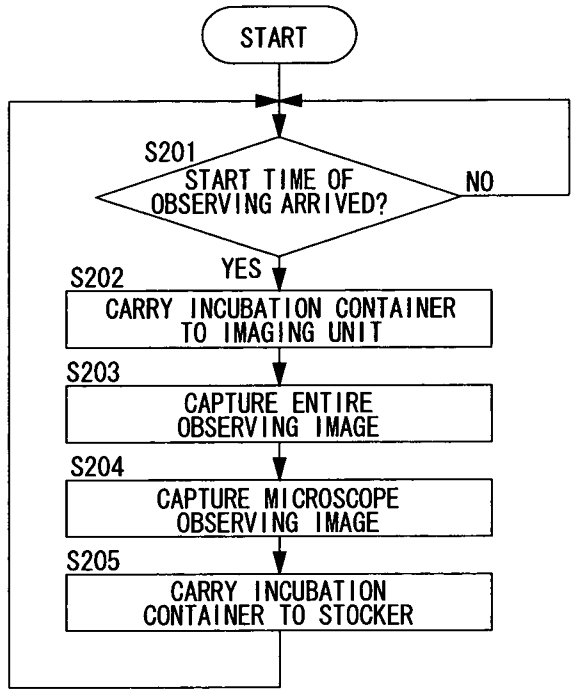

START
S201
START TIME OF OBSERVING ARRIVED?
NO
YES
S202
CARRY INCUBATION CONTAINER TO IMAGING UNIT
S203
CAPTURE ENTIRE OBSERVING IMAGE
S204
CAPTURE MICROSCOPE OBSERVING IMAGE
S205
CARRY INCUBATION CONTAINER TO STOCKER

FIG. 16

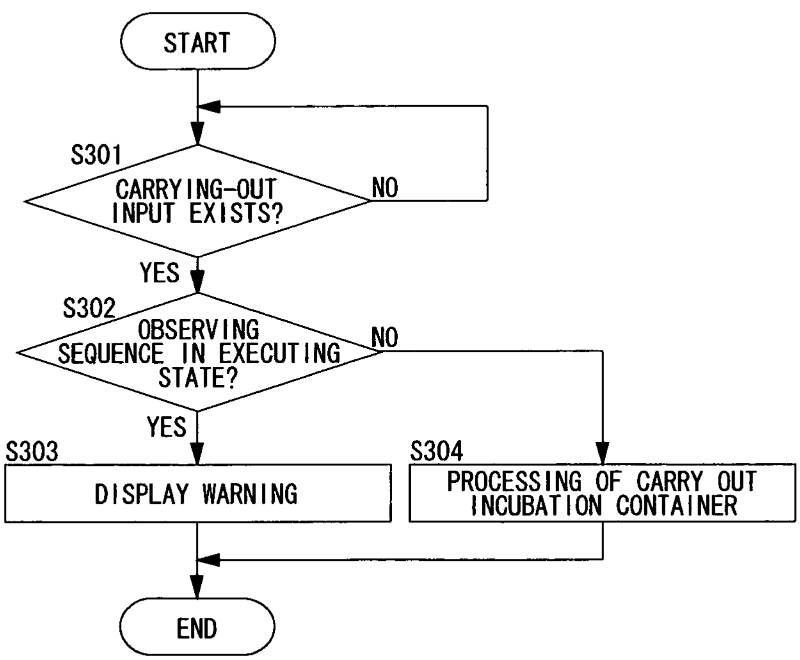

START
S301
CARRYING-OUT INPUT EXISTS?
NO
YES
S302
OBSERVING SEQUENCE IN EXECUTING STATE?
NO
YES
S303
DISPLAY WARNING
S304
PROCESSING OF CARRY OUT INCUBATION CONTAINER
END

FIG. 17

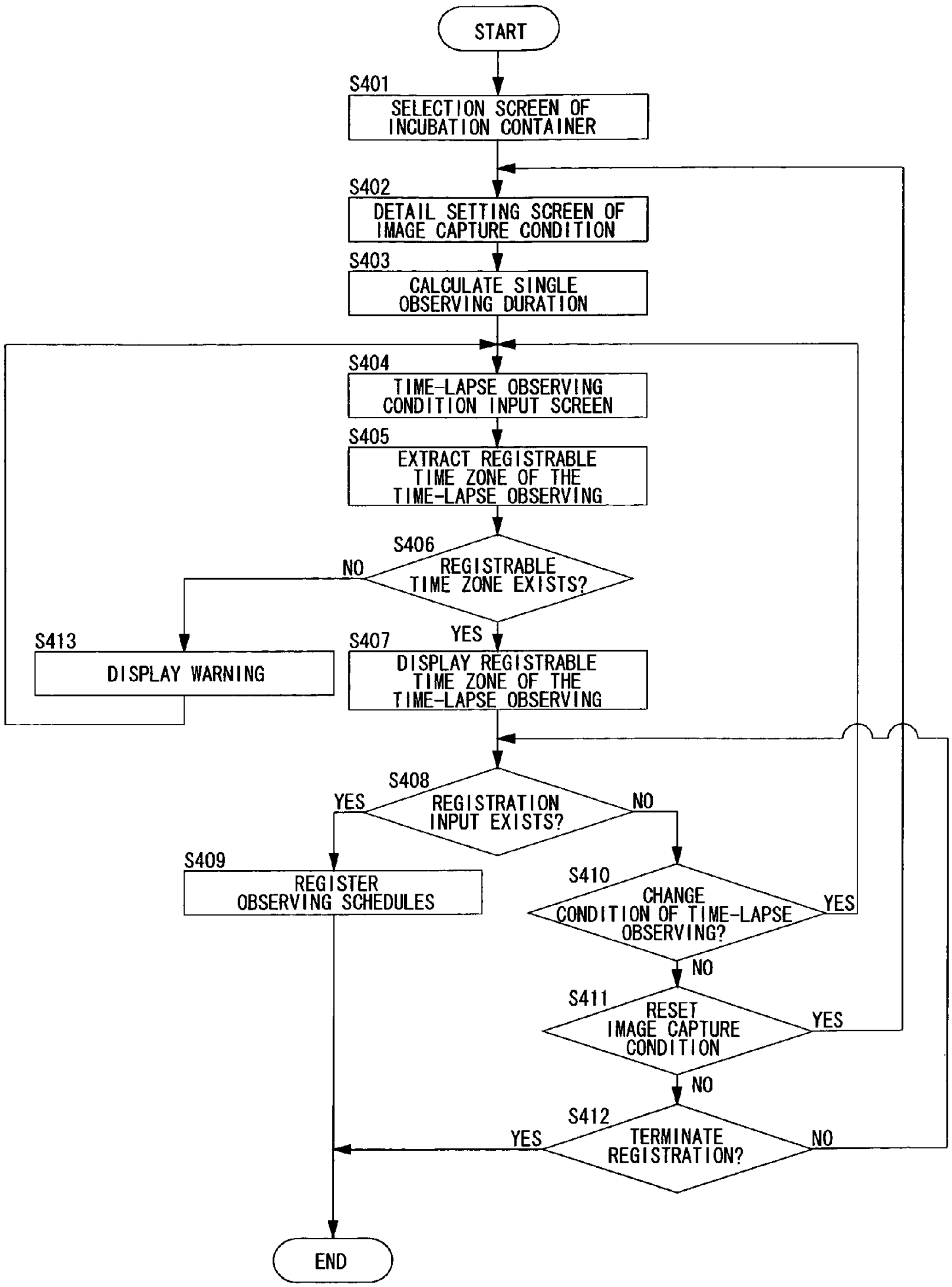

START
S401
SELECTION SCREEN OF INCUBATION CONTAINER
S402
DETAIL SETTING SCREEN OF IMAGE CAPTURE CONDITION
S403
CALCULATE SINGLE OBSERVING DURATION
S404
TIME-LAPSE OBSERVING CONDITION INPUT SCREEN
S405
EXTRACT REGISTRABLE TIME ZONE OF THE TIME-LAPSE OBSERVING
S406
REGISTRABLE TIME ZONE EXISTS?
NO
S413
DISPLAY WARNING
YES
S407
DISPLAY REGISTRABLE TIME ZONE OF THE TIME-LAPSE OBSERVING
S408
REGISTRATION INPUT EXISTS?
YES
NO
S409
REGISTER OBSERVING SCHEDULES
S410
CHANGE CONDITION OF TIME-LAPSE OBSERVING?
YES
NO
S411
RESET IMAGE CAPTURE CONDITION
YES
NO
S412
TERMINATE REGISTRATION?
YES
NO
END

FIG. 18

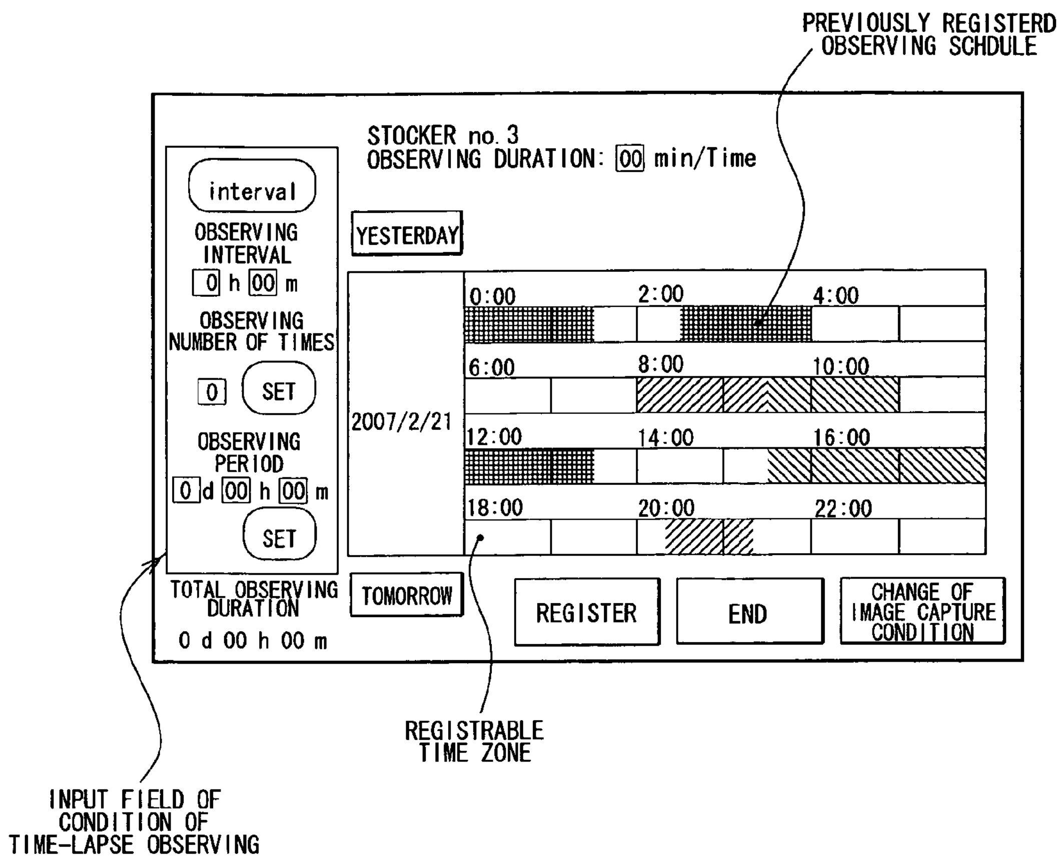

PREVIOUSLY REGISTERD OBSERVING SCHDULE
STOCKER no. 3
OBSERVING DURATION: 00 min/Time
interval
OBSERVING INTERVAL
0 h 00 m
OBSERVING NUMBER OF TIMES
0
SET
OBSERVING PERIOD
0 d 00 h 00 m
SET
TOTAL OBSERVING DURATION
0 d 00 h 00 m
YESTERDAY
TOMORROW
2007/2/21
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
REGISTER
END
CHANGE OF IMAGE CAPTURE CONDITION
REGISTRABLE TIME ZONE
INPUT FIELD OF CONDITION OF TIME-LAPSE OBSERVING

FIG. 19

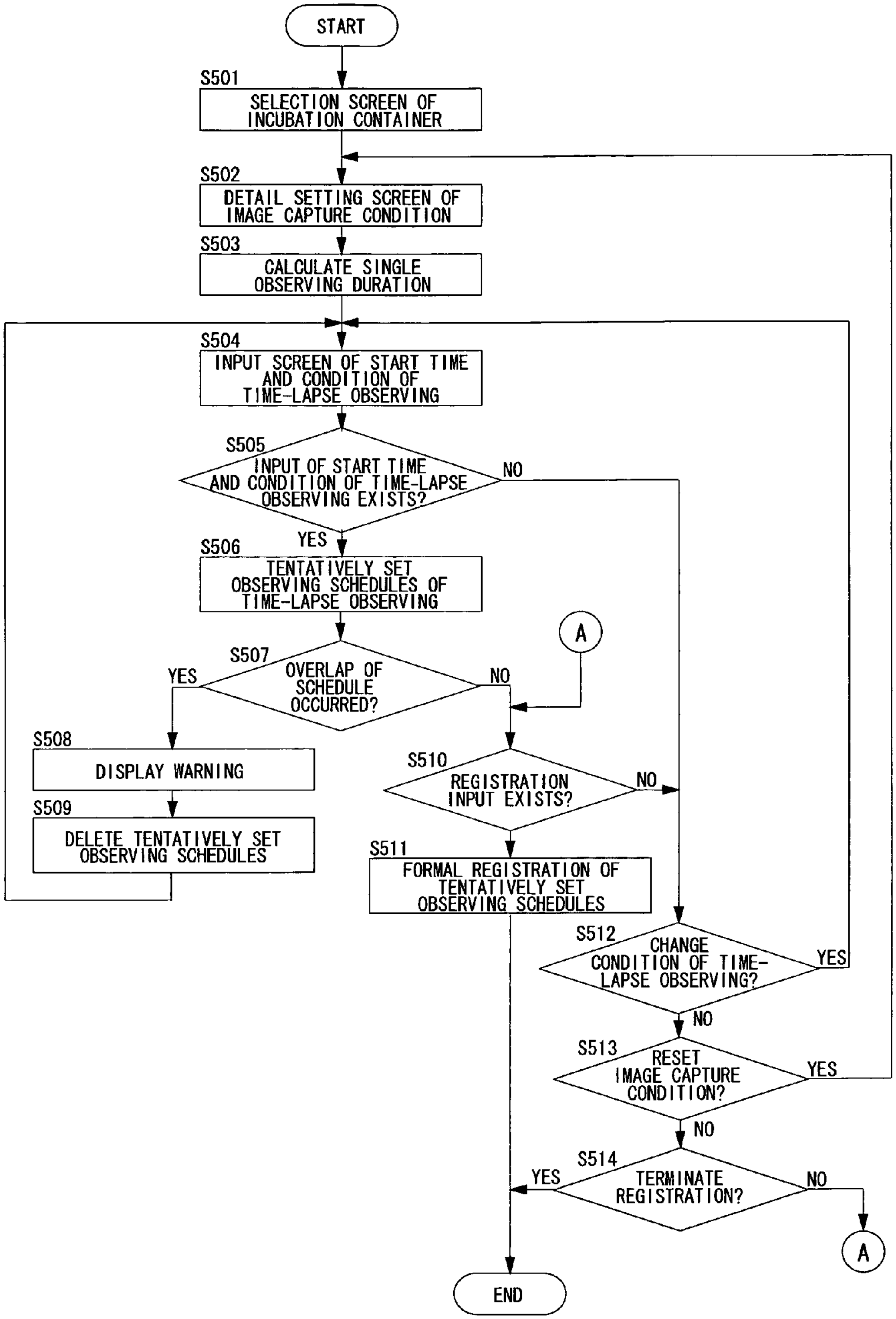

START
S501
SELECTION SCREEN OF INCUBATION CONTAINER
S502
DETAIL SETTING SCREEN OF IMAGE CAPTURE CONDITION
S503
CALCULATE SINGLE OBSERVING DURATION
S504
INPUT SCREEN OF START TIME AND CONDITION OF TIME-LAPSE OBSERVING
S505
INPUT OF START TIME AND CONDITION OF TIME-LAPSE OBSERVING EXISTS?
NO
YES
S506
TENTATIVELY SET OBSERVING SCHEDULES OF TIME-LAPSE OBSERVING
A
S507
OVERLAP OF SCHEDULE OCCURRED?
YES
NO
S508
DISPLAY WARNING
S509
DELETE TENTATIVELY SET OBSERVING SCHEDULES
S510
REGISTRATION INPUT EXISTS?
NO
S511
FORMAL REGISTRATION OF TENTATIVELY SET OBSERVING SCHEDULES
S512
CHANGE CONDITION OF TIME-LAPSE OBSERVING?
YES
NO
S513
RESET IMAGE CAPTURE CONDITION?
YES
NO
S514
TERMINATE REGISTRATION?
YES
NO
A
END

FIG. 20

INCUBATOR, SCHEDULE MANAGEMENT METHOD, AND PROGRAM

CROSS REFERENCE TO THE RELATED APPLICATIONS

This application is a continuation application of International Application PCT/JP2008/000349, filed Feb. 26, 2008, designating the U.S., and claims the benefit of priority from Japanese Patent Application No. 2007-049023, filed on Feb. 28, 2007, the entire contents of which are incorporate herein by reference.

BACKGROUND

1. Field

The present invention relates to an incubator comprising a temperature-controlled room which can maintain the environment condition suitable for incubating samples, and peripheral technology thereof.

2. Description of the Related Art

Incubators comprising a temperature-controlled room are generally used to incubate samples such as various microorganisms or cells. In such a temperature-controlled room, it is common to simultaneously incubate samples in a plurality of incubation containers.

On the other hand, it has been proposed to provide the incubator with a function of automatically observing the sample within the incubation container. For example, Patent Document 1 (Japanese Unexamined Patent Application Publication No. 2006-11415) discloses an arrangement of an incubation microscope which automatically executes time lapse observing of samples.

When automating the observation of samples in the incubator, it becomes very important to control the observing schedule. Particularly, overlap of observing schedules for a plurality of incubation containers may raise the possibility that samples can not be recorded with the time zone and number of times of observations desired by the user, whereby availability of the device substantially decreases. The above-mentioned Patent Document 1 has not sufficiently given consideration to prevent overlap of observing schedules, which leaves room for improvement at this point.

SUMMARY

The present invention is proposed to solve the above-mentioned problems in the prior-art. It is a proposition of the present invention to provide a means which can preliminarily prevent overlap of schedules for observing samples in the incubator.

A first Incubator of the invention includes a temperature-controlled room, an imaging section, a carrying mechanism, a controlling section, a first memory, a second memory, an input section, a calculating section, and a schedule management section. The temperature-controlled room has a storage section capable of housing a plurality of incubation containers, and can maintain its interior to a predefined environment condition. The imaging section captures images of the condition of samples within the incubation container in the temperature-controlled room. The carrying mechanism moves the incubation container between the storage section and the imaging section. The controlling section controls the imaging section and the carrying mechanism to automatically execute an observing sequence of the incubation container. The first memory records first data with regard to a carrying period of the incubation container by the carrying mechanism, and second data with regard to an imaging duration of the imaging section. The second memory records the schedule data. In the schedule data, an observing schedule indicating a start time and an observing duration of the observing sequence is registered in association with each of the incubation containers. The input section accepts, from the user, a first input selecting a specified incubation container for which the observing schedule is to be registered and a second input specifying an imaging condition of the specified incubation container in the observing sequence. The calculating section calculates the observing duration of the specified incubation container from the first data and the second data according to the imaging condition. The schedule management section extracts, based on the schedule data, a registrable time zone in which the observing sequence of the specified incubation container can be executed without overlapping with previously registered observing schedules. In addition, the schedule management outputs to display the registrable time zone for presentation to the user.

The second invention is arranged such that the schedule management section of the first invention registers, based on a user's input, the observing schedule of the specified incubation container into the schedule data, and disables registration of the observing schedule other than during the registrable time zone.

The third invention is arranged such that the calculating section of the second invention recalculates the observing duration of the specified incubation container if there is an input changing the imaging condition after registration of the observing schedule. In addition, the schedule management section outputs a notification to warn the user when overlap of observing schedules occurs due to increase of the observing duration.

The fourth invention is arranged such that the carrying mechanism of the first invention carries the incubation container out from the temperature-controlled room, according to the user's input. In addition, while the observing sequence of the incubation container to be carried out is being executed, the schedule management section outputs the notification to warn the user before carrying out the incubation container.

The fifth invention is arranged such that the schedule management section of the first invention displays a registration status of the observing schedule with regard to any of the incubation containers, based on the schedule data.

The sixth invention is arranged such that the incubator of the first invention further includes a communication section which can communicate with an external computer. The communication section then receives the first input and the second input from the computer, and transmits to the computer a display output indicating the registrable time zone.

The seventh invention is arranged such that the input section of the first invention further accepts a third input defining a condition of a time-lapse observing of the specified incubation container. In addition, the schedule management section sets a plurality of observing schedules of the specified incubation containers respectively having different observing times, according to the condition of the time-lapse observing. The schedule management section then extracts a registrable time zone in which each of the observing schedules of the time-lapse observing can be executed without overlapping with previously registered observing schedules.

The eighth invention is arranged such that the schedule management section of the seventh invention outputs to display, as the registrable time zone in the time-lapse observing, a first-time time zone of the time-lapse observing.

The ninth invention is arranged such that the schedule management section of the seventh invention outputs at least one of a warning and a presentation of the condition of the time-lapse observing for which the registrable time zone can be extracted, when the registrable time zone cannot be extracted.

The tenth invention is arranged such that the schedule management section of the seventh invention shifts one of the observing schedules of the time-lapse observing, when the registrable time zone cannot be extracted.

The incubator of the eleventh invention includes a temperature-controlled room, an imaging section, a carrying mechanism, a controlling section, a first memory, a second memory, an input section, a calculating section, and a schedule management section. The temperature-controlled room has a storage section capable of housing a plurality of incubation containers, and can maintain its interior to a predefined environment condition. The imaging section captures images of the condition of samples within the incubation container in the temperature-controlled room. The carrying mechanism moves the incubation container between the storage section and the imaging section. The controlling section controls the imaging section and the carrying mechanism to automatically execute an observing sequence of the incubation container. The first memory records first data with regard to carrying period of the incubation container by the carrying mechanism, and second data with regard to imaging duration of the imaging section. The second memory records the schedule data. In the schedule data, an observing schedule indicating a start time and an observing duration of the observing sequence is registered in association with each of the incubation containers. The input section accepts, from the user, a first input selecting a specified incubation container for which the observing schedule is to be registered, a second input specifying the imaging condition of the specified incubation container in the observing sequence, and a third input defining a condition of a time-lapse observing of the specified incubation container and the start time of the time-lapse observing. The calculating section calculates the observing duration of the specified incubation container from the first data and the second data, according to the imaging condition. The schedule management section tentatively sets a schedule of the time-lapse observing of the specified incubation container, according to the third input and the observing duration. In addition, the schedule management section determines, based on the schedule data, whether or not the tentatively set schedule of the time-lapse observing overlaps with previously registered observing schedules.

The twelfth invention is arranged such that the schedule management section of the eleventh invention outputs a warning if the schedule of the time-lapse observing overlaps with previously registered observing schedules.

The thirteenth invention is arranged such that the schedule management section of the twelfth invention resets the schedule of the time-lapse observing by modifying at least one of either the condition of the time-lapse observing or the start time of the time-lapse observing, when the schedule of the time-lapse observing overlaps with previously registered observing schedules.

The fourteenth invention is arranged such that the schedule management section of the twelfth invention outputs to display overlapping portions of the schedule, when the schedule of the time-lapse observing overlaps with previously registered observing schedules.

The fifteenth invention is arranged such that the schedule management section of the eleventh invention records the schedule of the time-lapse observing into the second memory, when the schedule of the time-lapse observing does not overlap with previously registered observing schedules.

Note that, those expressing the concept of respective inventions as interpretation into a schedule management method or a computer program relating to observation of incubation containers, are also effective as concrete aspects of the present invention.

According to an aspect of the present invention, a registrable time zone which does not overlap with previously registered observing schedules is presented to the user, based on the observing duration according to the imaging condition, whereby overlap of schedules can be preliminarily prevented.

In addition, according to another aspect of the present invention, registration of a schedule of the time-lapse observing which causes overlapping with previously registered observing schedules can be preliminarily prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of the incubator of a first embodiment;

FIG. **2** is a front view of the incubator of the first embodiment;

FIG. **3** illustrates the front door of FIG. **2** in the open state;

FIG. **4** illustrates the interior of the temperature-controlled room of the first enclosure;

FIG. **5** illustrates the stocker seen from the side direction of the enclosure;

FIGS. **6** (*a*) to **6** (*c*) each illustrates an exemplary incubation container which incubates samples;

FIG. **7** (*a*) illustrates the container carrying mechanism from the frontal direction of the enclosure, and FIG. **7** (*b*) illustrates the container carrying mechanism from the planer direction of the enclosure;

FIG. **8** is a front view illustrating the arrangement of the carrier arm section;

FIG. **9** is a side view illustrating the arrangement of the carrier arm section;

FIG. **10** is a schematic view illustrating the arrangement of the observing unit;

FIG. **11** is a flow chart explaining the operation of the CPU in the registration processing of the observing schedule;

FIG. **12** illustrates an exemplary selection screen in S**104**;

FIG. **13** illustrates an exemplary detail setting screen of imaging condition in S**105**;

FIG. **14** illustrates an exemplary display screen of the registrable time zone in S**108**;

FIG. **15** illustrates a display screen of the registration status of observing schedule relating to predefined incubation container;

FIG. **16** is a flow chart explaining the operation of the CPU in the observing sequence;

FIG. **17** is a flow chart explaining the operation of the CPU when carrying the incubation container out;

FIG. **18** is a flow chart illustrating the registration processing of the observing schedule according to a variation of the first embodiment;

FIG. **19** illustrates an exemplary display screen relating to time-lapse observing; and

FIG. **20** is a flow chart illustrating the registration processing of the observing schedule relating to a second embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Description of First Embodiment

(Arrangement of Incubator of First Embodiment)

An arrangement of the incubator of a first embodiment will be described below in detail, referring to the drawings. FIG. **1** is a block diagram of the incubator of the first embodiment. Additionally, FIGS. **2** and **3** are front views of the incubator of the first embodiment.

The incubator **11** of the first embodiment has a first enclosure **12** which incubates samples and a second enclosure **13** which houses a controlling unit **14**. In the assembled state of the incubator **11**, the first enclosure **12** is disposed on the second enclosure **13**.

First, the general arrangement of the first enclosure **12** will be described.

A temperature-controlled room **15** covered with heat insulating material is formed inside the first enclosure **12**. The temperature-controlled room **15** is in communication with the outside by a front opening **16** formed on the front face of the first enclosure **12** and a carrying in-and-out opening **17** formed on the left side face of the first enclosure **12** shown in FIGS. **2** and **3**. The front opening **16** of the first enclosure **12** is covered by a clamshell front door **18** so that it can be opened or closed. In addition, the carrying in-and-out opening **17** of the first enclosure **12** is covered by a sliding automatic door **19** so that it can be opened or closed. Here, the size of the carrying in-and-out opening **17** is defined such that an incubation container (**30**) can pass through. An opening **20** is formed at the right-hand side of the base of the first enclosure **12** seen from the front face. In addition, an observing section (**28**) described below is disposed inside the temperature-controlled room **15** via the above-mentioned opening **20**.

FIG. **4** illustrates the interior of the temperature-controlled room **15** of the first enclosure **12**. On the wall surface of the temperature-controlled room **15**, a temperature regulating device **21**, a spraying device **22**, a gas introducing section **23**, and an environment sensor unit **24** are built-in, respectively.

The temperature regulating device **21**, having a Peltier element, heats and cools the temperature-controlled room **15** using Peltier effect. The spraying device **22** sprays inside the temperature-controlled room **15** to regulate the humidity inside the temperature-controlled room **15**. The gas introducing section **23** is coupled to a carbon dioxide tank (not shown). The gas introducing section **23** regulates carbon dioxide concentration inside the temperature-controlled room **15** by introducing carbon dioxide into the temperature-controlled room **15**. The environment sensor unit **24** detects temperature, humidity, and carbon dioxide concentration, respectively, inside the temperature-controlled room **15**.

Returning to FIGS. **2** and **3**, in the assembled state of the incubator **11**, a stocker **25**, a container carrying in-and-out mechanism **26**, a container carrying mechanism **27**, and a part of the observing unit **28** are respectively disposed inside the temperature-controlled room **15**.

The stocker **25** is disposed on the left hand side of the temperature-controlled room **15** seen from the front face of the first enclosure **12**. FIG. **5** illustrates the stocker **25** seen from the side face direction of the enclosure. The stocker **25** has a plurality of shelves, each of which capable of housing the incubation container **30**. Here, FIGS. **6** (*a*) to **6** (*c*) each illustrates an exemplary arrangement of the incubation container **30** which incubates samples. A well plate, a flask, a dish or the like are used as the incubation container **30** of the first embodiment. Each incubation container **30** contains a sample (such as cell) to be incubated as well as the liquid culture medium. In addition, the above-mentioned incubation container **30** is placed and handled on a transparent tray-like holder **31**. A supporting piece **32** facing outward is formed on each of both sides of the holder **31**. Note that the incubation container **30** may have, depending on its type, a plurality of small containers, in which case each of the small containers can incubate a sample on a single holder **31**.

Additionally, in the assembled state of the incubator **11**, the lowest level of the stocker **25** corresponds to the position of the first carrying in-and-out opening **17** of the enclosure **12**. A container carrying in-and-out mechanism **26** which carries the incubation container **30** is disposed in the space of the lowest level of the stocker **25**. The container carrying in-and-out mechanism **26** has a carrying table **26***a* capable of placing the incubation container **30** and a holder **31**, and a motor unit **26***b* which causes the carrying table **26***a* to move outside of the carrying in-and-out opening **17**, reciprocatingly.

A container carrying mechanism **27** is disposed at the center of the temperature-controlled room **15** seen from the front face of the first enclosure **12**. FIGS. **7** to **9** illustrate an arrangement of the container carrying mechanism **27**. The container carrying mechanism **27** has a rectangular base platform **41**, a vertical frame **42**, and a carrier arm section **43**. Here, each part of the container carrying mechanism **27** is driven by a motor (not shown) which is built in the base platform **41** or the like. In addition, position of each part of the container carrying mechanism **27** is monitored by a controlling unit **14** using an encoder or the like.

A vertical frame **42** is mounted on the base platform **41** movably forward and backward (Y-direction in the figure). The vertical frame **42** includes a pair of guide rails extending upward and downward. A carrying arm section **43** is provided movably upward and downward (Z-direction in the figure) between the vertical frame **42**.

In addition, the carrying arm section **43** has a container supporting section **44** and a sliding mechanism **45**. The main body of the container supporting section **44** is made slightly wider than the entire width of the holder **31**. A pair of hook nails **46** are formed downward at both side edges of the container supporting section **44**. Thus, the container supporting section **44** is arranged so that it can support the holder **31** by engagement between the supporting piece **32** of the holder **31** and the hook nail **46**. On the other hand, the sliding mechanism **45**, disposed on the top face of the container supporting section **44**, causes the container supporting section **44** to slide horizontally (X-direction in the figure). Due to such movement of the sliding mechanism **45**, it becomes possible to pass the holder **31** having the incubation container **30** placed thereon between the container carrying mechanism **27** and any one of the stocker **25**, the container carrying in-and-out mechanism **26**, or the observing unit **28**.

The observing unit **28** is disposed at the right-hand side of the temperature-controlled room **15** seen from the front face of the first enclosure **12**. The observing unit **28** is fitted into the opening **20** at the bottom of the first enclosure **12**. The observing unit **28** has a sample stage **47**, an arm **48** protruding above the sample stage **47**, and a main body **49**. Then, the sample stage **47** and the arm **48** are disposed inside the temperature-controlled room **15** of the first enclosure **12**, whereas the main body **49** is housed in the second enclosure **13**.

FIG. **10** is a schematic view illustrating an arrangement of the observing unit **28**. The observing unit **28** has a sample stage **47**, a first lighting section **51** and a second lighting section **52**, a microscope observing section **53**, a container observing section **54**, and an image processing section **55**.

The sample stage **47** is made of translucent material, with an incubation container **30** placed thereon together with the holder **31**. The sample stage **47** is arranged movably horizontally (X-direction and Y-direction) so that it can adjust the position of the holder **31** relative to the microscope observing section **53** and the container observing section **54**.

In addition, the first lighting section **51**, which is disposed inside the arm **48**, illuminates the incubation container **30** from above the sample stage **47**. On the other hand, the second lighting section **52**, which is built-in the main body **49**, illuminates the incubation container **30** from below the sample stage **47**.

The microscope observing section **53**, which is built in the main body **49**, has a microscope optical system and an image pickup device (all of which are not illustrated). The microscope observing section **53** captures images of samples observed through the microscope (microscope observing image) with the help of illumination light of the first lighting section **51**.

The container observing section **54**, which is housed in the arm **48**, has an optical imaging system and an image pickup device (all of which are not illustrated). The container observing section **54** captures the entire observing image of the incubation container **30** with the help of illumination light of the second lighting section **52**.

The image processing section **55** executes A/D conversion of images output from the microscope observing section **53** and the container observing section **54**, and generates data of microscope observing images or entire observing images, respectively.

Next, the arrangement of the second enclosure **13** will be described in general. In the second enclosure **13**, the main body **49** of the observing unit **28** and the controlling unit **14** are housed. In addition, an operation panel **56** comprising a monitor **56*a*** and an input button **56*b*** is disposed on the front face of the second enclosure **13**. A computer **58** can be coupled to the controlling unit **14** via a communication line **57**.

Here, the controlling unit **14** is coupled to a door opening and closing mechanism **19*a*** of the automatic door **19**, a temperature regulating device **21**, a spraying device **22**, a gas introducing section **23**, an environment sensor unit **24**, a container carrying in-and-out mechanism **26**, a container carrying mechanism **27**, an observing unit **28**, a monitor **56*a*** and an input button **56*b*** of the operation panel **56**, respectively. The controlling unit **14** executes overall control of each part of the incubator **11** according to a predefined program.

As an example, the controlling unit **14** controls the temperature regulating device **21**, the spraying device **22**, the gas introducing section **23**, and the environment sensor unit **24** respectively, to maintain the temperature-controlled room **15** at a predefined environment condition. In addition, the controlling unit **14** controls the observing unit **28** and the container carrying mechanism **27** based on the observing schedule set by the user to automatically execute the observing sequence of the incubation container **30**.

Here, the controlling unit **14** has a communication section **61**, a data base section **62**, a first memory **63** and a second memory **64**, and a CPU **65**. The communication section **61**, the data base section **62**, the first memory **63** and the second memory **64** are coupled to the CPU **65**, respectively.

The communication section **61** executes transmission and reception of data between the computer **58** outside the incubator **11** via a wireless or wired communication line **57**.

The data base section **62** records management data with regard to each of the incubation containers **30** housed in the stocker **25**. The management data includes, for example, identification information of the incubation container **30** and the holder **31**, type and shape of the incubation container **30**, housing position of the incubation container **30** in the stocker **25**, or the like.

In addition, a recording area for recording data files of microscope observing images and entire observing image and history information of environment condition (temperature, humidity, carbon dioxide concentration) inside the temperature-controlled room **15** is provided in the data base region **62**. Here, in the above-mentioned data file, metadata indicating the identification information of the image-captured incubation container **30**, time and date of image capturing, condition of image capturing or the like is associated with the image data.

The first memory **63** has a variety of data recorded therein to calculate the observing duration in the observing sequence. For example, the first memory **63** has first data with regard to carrying period of the incubation container **30** and second data with regard to duration of the imaging operation by the observing unit **28** recorded therein, respectively.

More specifically, carrying period of the first data is calculated by adding the time required for the container carrying mechanism **27** to carry the incubation container **30** from the stocker **25** to the observing unit **28** and the time corresponding to error margin. Although the carrying period of the incubation container **30** varies according to the housing position in the stocker **25**, the above-mentioned carrying period is determined based on the case where the incubation container **30** is placed at the farthest position from the observing unit **28** (maximum value of respective carrying periods) in the first embodiment.

In addition, the second data has a table recorded therein, indicating the correspondence between the operation parameter with regard to the observing unit **28** and the duration corresponding to the parameter.

As an example, the second data of the first embodiment includes items such as (1) imaging period of the entire observing image by the container observing section **54**, (2) positioning period of guiding the incubation container **30** to a predefined imaging position, (3) AF operation period of the microscope observing section **53** and the container observing section **54**, (4) required time for changing the magnification of the objective lens of the microscope observing section **53**, (5) imaging period when capturing images of a plurality of frames by changing the position of the microscope observing section **53** and the sample along the height direction, or the like. For each of the items (1) to (5) of the second data, values of duration are set, respectively, according to parameters such as imaging condition, device arrangement, and shape of the incubation container **30** or the like.

The second memory **64** has the schedule data of the above-mentioned observing sequence recorded therein. The schedule data has observing schedules indicating the start time and observing duration of each observing sequence recorded therein in association with the identification information of each holder **31**. Here, each observing schedule is associated with data setting the imaging condition of the observing unit **28** in the observing sequence.

The CPU **65** is a processor which executes a variety of calculations of the controlling unit **14**. The CPU **65** serves as the calculating section **66** which calculates the observing duration of the incubation container **30** and the schedule management section **67** which registers the observing schedule, in the registration processing of the observing schedule described below. Furthermore, the CPU **65** serves as a timer **68** for managing the observing schedule.

(Description of Registration Processing of Observing Schedule)

In the following, operation of the CPU **65** in the registration processing of the observing schedule will be described, referring to the flow chart of FIG. **11**. Here, the registration manipulation of the observing schedule of the incubation container **30** is performed by the user from the operation panel **56** of the incubator **11** or from the computer **58** coupled to the incubator **11**.

Step **101**: The CPU **65** of the controlling unit **14** initiates the registration processing of the observing schedule in response to the user's manipulation. In this occasion, the CPU **65** displays a prompt to select among "newly register observing schedule", "change previously registered observing schedule", and "terminate registration processing", on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). The CPU **65** then proceeds to S**102** upon accepting any of the selection inputs of the above-mentioned items from the input button **56***b* of the operation panel **56** (or an input device of the computer **58**).

Step **102**: The CPU **65** determines whether or not an input to "terminate registration processing" is accepted. If the above condition is satisfied (the case of YES), the CPU **65** terminates the registration processing of the observing schedule. If, on the other hand, an input selecting another item is accepted (the case of NO), the CPU **65** proceeds to S**103**.

Step **103**: The CPU **65** determines whether or not an input to "newly register observing schedule" is accepted. If the above condition is satisfied (the case of YES), the CPU **65** proceeds to S**104**. If, on the other hand, the input to "change previously registered observing schedule" is accepted (the case of NO), the CPU **65** proceeds to S**113**.

Step **104**: The CPU **65** displays a selection screen letting the user select an incubation container **30** for which an observing schedule is to be set, on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**).

Here, an exemplary selection screen in S**104** is shown in FIG. **12**. On the selection screen, an incubation container **30** for which an observing schedule is to be set is displayed as an icon of GUI (Graphical User Interface) form. The location of the icon on selection screen corresponds to the location of the incubation container **30** in the stocker **25**. Then, the user can specify, to the CPU **65**, the incubation container **30** for which an observing schedule is to be set, by selecting the above-mentioned icon. Here, the CPU **65** proceeds to S**105** upon accepting an input selecting the incubation container **30** in S**104**.

In the selection screen of FIG. **12**, a classification mark indicating the type of the incubation container **30** is displayed on each icon. Furthermore, a camera-shaped mark is displayed on the icon of an incubation container **30** having an observing schedule registered in the schedule data. In addition, when the incubator **11** is used by a plurality of users, each of the incubation containers **30** may have user IDs registered therewith. In this case, only the incubation container **30** corresponding to the user ID will have an observing schedule set thereto on the selection screen of FIG. **12**. Here, the user's input in the selection screen is provided from the input button **56***b* of the operation panel **56** (or an input device of the computer **58**).

Step **105**: The CPU **65** displays the detail setting screen of imaging condition on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**).

Here, an exemplary detail setting screen of imaging condition in S**105** is shown in FIG. **13**. In the detail setting screen of imaging condition, an icon indicating the shape of the incubation container **30** is displayed on the left half of the screen. In addition, an icon for specifying the imaging condition is displayed on the right half of the detail setting screen.

With the icon indicating the shape of the incubation container **30**, the user can instruct the CPU **65** which of the containers should be image-captured when there are a plurality of containers on the holder **31**.

On the other hand, with the icon on the right half of the detailed setting screen, the user can specify, to the CPU **65**, (1) the magnification (2-, 4-, 10-, 20-times) of the objective lens of the microscope observing section **53**, and (2) the observing point in the container. Additionally, the user's selecting a default item of FIG. **13** is followed by an input into the CPU **65** of an initially set imaging condition (for example, five-point observing by a 10- or 20-times objective lens). Here, the observing point may be customized by the user.

In addition, when the detail setting screen of imaging condition is displayed, the user can simultaneously define the number of frames of the microscope observing image to be image-captured by the microscope observing section **53**. Here, the user's input in the detail setting screen of imaging condition is provided from the input button **56***b* of the operation panel **56** (or an input device of the computer **58**).

Step **106**: The CPU **65** calculates the observing duration of the incubation container **30**.

Specifically, the CPU **65** acquires, from the first data of the first memory **63**, the carrying period for a round trip of the incubation container **30** in the observing sequence. Additionally, based on the imaging condition set in S**105**, the CPU **65** acquires the duration corresponding to the parameter of imaging condition from the second data of the first memory **63**. The CPU **65** then adds the duration acquired from the first data and the second data. Subsequently, the CPU **65** rounds up the fraction of the above-mentioned duration so that it becomes a multiple number of the unit time (10 minutes, for example) of the schedule data to acquire the final observing duration.

Step **107**: The CPU **65** extracts a registrable time zone. Specifically, the CPU **65** first extracts, from the schedule data of the second memory **64**, all the idle-time having no observing schedule registered therein. Then the CPU **65** extracts, from the above-mentioned idle-time, time zones equal to or longer than the observing duration (the one acquired in S**106**) as registrable time zones.

Here, when observing schedules of incubation containers **30** having a common holder **31** are registered in succession, the processing of carrying the incubation container **30** into and out from the stocker **25** between two observing schedules becomes needless.

Therefore, in the above case, the CPU **65** calculates the registrable time zone after preliminarily subtracting the carrying period in one of the observing schedules.

Step **108**: The CPU **65** displays, on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**) the registrable time zone acquired in S**107**.

Here, an exemplary display screen of the registrable time zone in S**108** is shown in FIG. **14**. On the display screen of the registrable time zone, the previously registered observing schedule and the above-mentioned registrable time zone are displayed as a list. In FIG. **14**, the previously registered observing schedule is shown by hatching, whereas the registrable time zone is shown as blank fields.

Then, the user can register an observing schedule in the second memory **64** by specifying a desired time zone among the registrable time zones. Here, the user's input on the display screen of the registrable time zones is performed via the input button **56***b* of the operation panel **56** (or an input device of the computer **58**).

Here, on the display screen of registrable time zones, the CPU **65** preliminarily disables registration of an observing schedule other than during the registrable time zone. In other words, registration of a new observing schedule in a time zone overlapping with previously registered observing schedules is prohibited in the display screen of registrable time zones.

Step **109**: The CPU **65** determines whether or not an input to register an observing schedule (for example, input via the registration button in FIG. **14**) is accepted with the display screen of S**108** being displayed. If an observing schedule is registered (the case of YES), the CPU **65** proceeds to S**110**. If, on the other hand, no observing schedule is registered (the case of NO), CPU **65** proceeds to S**111**.

Step **110**: The CPU **65** registers the observing schedule in the schedule data of the second memory **64**. Here, according to the user's manipulation, the CPU **65** can also display a list of registration status of observing schedules relating to any of the incubation containers **30** (see. FIG. **15**) on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). Displaying the list of observing schedules allows the user to grasp the observing schedule of the incubation container **30** more easily, whereby enhancing user-friendliness of the device.

Step **111**: The CPU **65** determines whether or not an input to reset the imaging condition (for example, input via the change imaging condition button in FIG. **14**) is accepted with the display screen of S**108** being displayed. If there is an input to reset the imaging condition (the case of YES), the CPU **65** returns to S**105** and repeats the above-mentioned operation. If, on the other hand, there is no input to reset the imaging condition (the case of NO), the CPU **65** proceeds to S**112**.

Step **112**: The CPU **65** determines whether or not an input to terminate the registration (for example, input from END button in FIG. **14**) is accepted with the display screen of S**108** being displayed. If there is an input to terminate the registration (the case of YES), the CPU **65** returns to S**102** and repeats the above-mentioned operation.

If, on the other hand, there is no input ending the registration (the case of NO), the CPU **65** returns to S**109** and repeats the above-mentioned operation. That is, in this case (the case of NO in S**112**), the user is allowed to sequentially register, on the display screen of S**108**, observing schedules with regard to the same incubation container **30** in the CPU **65**.

Step **113**: The CPU **65** displays a screen for accepting selection of the observing schedule to be changed on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). For example, the CPU **65** displays in S**113** a display screen listing the observing schedules (the screen substantially similar to FIG. **14**), letting the user directly specify an observing schedule to be changed.

The CPU **65** in S**113** may let the user select an incubation container **30** in the selection screen of FIG. **12** to narrow down the previously registered observing schedules and subsequently, let the user specify an observing schedule to be changed.

Step **114**: The CPU **65** determines whether or not an input to stop changing the observing schedule is accepted. If there is an input to stop changing (the case of YES), the CPU **65** returns to S**102** and repeats the above-mentioned operation. If, on the other hand, there is an input specifying an observing schedule to be changed (the case of NO), the CPU **65** proceeds to S**115**.

Step **115**: If an observing schedule to be changed is specified in S**113**, the CPU **65** displays the detail setting screen of imaging condition on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). Then, the user changes the imaging condition in the observing schedule on the detail setting screen of imaging condition. Here, since the operation of the CPU **65** in S**115** is common with that in S**105**, duplicate description is omitted.

Step **116**: The CPU **65** calculates the observing duration of the incubation container **30** again, according to the change of imaging condition in S**115**. Here, since the operation of the CPU **65** in S**116** is common with that in S**106**, duplicate description is omitted.

Step **117**: The CPU **65** determines whether or not the observing duration acquired in S**116** has increased from that before the change. If the observing duration has increased (the case of YES), the CPU **65** proceeds to S**118**. If, on the other hand, the observing duration is the same with, or has decreased from, before the change (the case of NO), the CPU **65** proceeds to S**120**.

Step **118**: The CPU **65** determines whether or not overlap with other observing schedules set in the preceding or following time zone occurs due to increase of the observing duration of the observing schedule to be changed. If overlap of observing schedules occurs (the case of YES), the CPU **65** proceeds to S**119**. If, on the other hand, no overlap of observing schedules occurs (the case of NO), the CPU **65** proceeds to S**120**.

Step **119**: The CPU **65** displays a warning that overlap of schedules occurs on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). Subsequently, the CPU **65** returns to S**114** without registering the observing schedule after change. In this case, the user must either cancel the change of the observing schedule or reset the imaging condition again.

Step **120**: The CPU **65** registers the observing schedule after change by overwriting the schedule data of the second memory **64**. In other words, since overlap of observing schedules does not occur in this case, the CPU **65** registers the observing schedule after change as it is. Subsequently, the CPU **65** returns to S**102** and repeats the above-mentioned operation. Description of the flow chart of FIG. **11** is thus completed.

In the first embodiment, the CPU **65** calculates the observing duration of the incubation container **30** according to the imaging condition specified by the user. The CPU **65** then extracts a registrable time zone in which the observing sequence can be executed without overlapping with previously registered observing schedules, and displays the result on the monitor. Therefore, overlap of observing schedules of the incubation containers **30** can be preliminarily prevented by the user's selecting a time for executing the observing sequence from registrable time zones. Particularly, since the CPU **65** in the first embodiment preliminarily disables observing schedules other than those during a registrable time zone, overlap of observing schedules can be prevented more certainly.

Additionally, since the CPU **65** in the first embodiment provides a warning if overlap with other observing schedules occurs due to increase of observing duration when changing the previously registered observing schedule, overlap of observing schedules of the incubation containers **30** can be prevented more certainly.

Here, in the first embodiment, since the user can also register an observing schedule from a remote computer **58** coupled to the incubator **11** via a communication line **57**, convenience of the device is enhanced.

(Description of Operation of Observing Sequence)

Next, operation of the CPU **65** in the above-mentioned observing sequence will be described, referring to the flow chart of FIG. **16**.

Step **201**: The CPU **65** compares the observing schedule of the second memory **64** with the current time and date, and determines whether or not start time of observing the incubation container **30** has arrived. If the start time of observation has arrived (the case of YES), the CPU **65** proceeds to S**202**. If, on the other hand, it is not the start time of observing the incubation container **30** (the case of NO), the CPU **65** waits until the time of next observing schedule.

Step **202**: The CPU **65** instructs the container carrying mechanism **27** to carry the incubation container **30** corresponding to the observing schedule. The container carrying mechanism **27** then carries out the specified incubation container **30** from the stocker **25**, and places in on the sample stage **47** of the observing unit **28**.

Step **203**: The CPU **65** instructs the observing unit **28** to capture the entire observing image. The observing unit **28** turns on the second lighting section **52** to illuminate the incubation container **30**, and captures the entire observing image of the incubation container **30** via the image pickup device of the container observing section **54**.

Step **204**: The CPU **65** instructs the observing unit **28** to capture the microscope observing image. The observing unit **28** turns on the first lighting section **51** to illuminate the incubation container **30**, and captures the microscope observing image of the incubation container **30** via the image pickup device of the microscope observing section **53**. In this occasion, the observing unit **28** captures the microscope observing image with an imaging condition (magnification of the objective lens, observing point inside the container, number of frames, etc) set by the user, based on the data of the observing schedule registered in the second memory **64**.

Step **205**: After the microscope observing image has been finished, The CPU **65** instructs the container carrying mechanism **27** to carry the incubation container **30**. The container carrying mechanism **27** carries the specified incubation container **30** from the sample stage **47** of the observing unit **28** to a predefined housing position of the stocker **25**, then terminates the observing sequence and proceeds to S**201**. Description of the flow chart of FIG. **16** is thus completed.

As thus described, with the incubator **11** of the first embodiment, automatic observing of samples in the incubation container **30** can be executed, based on the observing schedule.

(Description of Operation when Carrying Out the Incubation Container)

Next, operation of the CPU **65** when carrying out the incubation container **30** will be described, referring to the flow chart of FIG. **17**.

Step **301**: The CPU **65** determines whether or not an input that instructs to carry out the incubation container **30** is accepted from the input button **56***b* of the operation panel **56**. If an input that instructs to carry out the incubation container **30** is accepted (the case of YES), the CPU **65** proceeds to S**302**. If, on the other hand, there is no such input (the case of NO), the CPU **65** waits for an input that instructs to carry out the incubation container **30**.

Step **302**: The CPU **65** determines whether or not the incubation container **30** specified to be carried out by the carrying-out instruction input in S**301** is in an executing state of the observing sequence. In the determination of S**302**, the CPU **65** may refer to the schedule data and regard the case as the above-mentioned executing state, in which the observing sequence is started within a certain period.

If the container to be carried out is in the execution state of the observing sequence (the case of YES), the CPU **65** proceeds to S**303**. If, on the other hand, the container to be carried out is not in the executing state (the case of NO), the CPU **65** proceeds to S**304**.

Step **303**: The CPU **65** displays a warning that the container to be carried out is in an executing state of the observing sequence on the monitor **56***a* of the operation panel **56**. Additionally, if a warning is displayed, the CPU **65** requires the user to provide an input confirming whether or not to carry out the incubation container **30** which is in an executing state of the observing sequence. The CPU **65** then carries the incubation container **30** out of the temperature-controlled room **15** by a process substantially similar to that of S**304** which will be described below, only when the user chose to carry out the incubation container **30** in the above-mentioned confirmation input.

Such a warning display and confirmation input significantly reduce the risk that the user carries out the incubation container **30** by mistake during execution of the observing sequence.

Step **304**: The CPU **65** instructs the container carrying in-and-out mechanism **26** and the container carrying mechanism **27** to discharge the incubation container **30** to be carried out from the temperature-controlled room **15**. The container carrying mechanism **27** passes the specified incubation container **30** from the stocker **25** to the container carrying in-and-out mechanism **26**. Then the CPU **65** opens the automatic door **19** of the carrying in-and-out opening **17**, and causes the container carrying in-and-out mechanism **26** to discharge the incubation container **30** out of the temperature-controlled room **15**. Description of the flow chart of FIG. **17** is thus completed.

(Description of an Exemplary Variation of the Registration Processing of the Observing Schedule)

Additionally, FIG. **18** shows an exemplary variation of the registration processing of the observing schedule. Here, since the arrangement of the incubator in the exemplary operation of FIG. **18** is common with the above-mentioned embodiment, duplicate description is omitted.

In the example of FIG. **18**, the CPU **65** can execute collective registration of the observing schedule of the time-lapse observing. Here, for simplicity in the example of FIG. **18**, description is given assuming the case of "newly registering an observing schedule".

Step **401**: The CPU **65** displays a selection screen letting the user select an incubation container **30** for which an observing schedule is to be set on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). Here, since the processing in S**401** is common with that in S**104** of FIG. **11**, duplicate description will be omitted.

Step **402**: The CPU **65** displays the detail setting screen of imaging condition on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). Here, since the processing in S**402** is common with that in S**105** of FIG. **11**, duplicate description is omitted.

Step **403**: The CPU **65** calculates the observing duration of a single time-lapse observing, based on the inputs in S**401** and S**402**. Here, since the processing in S**403** is common with that in S**106** of FIG. **11**, duplicate description is omitted.

Step **404**: The CPU **65** displays a screen for accepting an input of the condition of the time-lapse observing on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**).

Here, an exemplary display screen in S**404** is shown in FIG. **19**. In the display screen (left-hand side of the screen of FIG. **19**), interval, number of times, and period of the time-lapse observing can be input as the condition of the time-lapse observing. Then, the CPU **65** proceeds to S**405**, if (1) the SET button on the screen is pressed with the interval and number of times of the time-lapse observing having been input, or (2) the SET button on the screen is pressed with the interval and period of the time-lapse observing having been input. Here, the user's input on the display screen is performed from the input button **56***b* of the operation panel **56** (or an input device of the computer **58**).

Step **405**: The CPU **65** extracts a registrable time zone of the time-lapse observing, based on the condition of the time-lapse observing (S**404**). Specifically, the CPU **65** executes the following processing (1) to (4) in S**405**.

(1) The CPU **65** extracts, from the schedule data of the second memory **64**, an idle-time having no observing schedule registered and being equal to or longer than the observing duration (acquired in S**403**).

(2) The CPU **65** tentatively sets a plurality of observing schedules of the incubation container **30**, according to the time interval and number of times (or period) under the condition (S**404**) of the time-lapse observing, setting an arbitrary time-point in the above-mentioned idle-time (1) as the start time. Here, the period of a single observing schedule in the tentative setting corresponds to the observing duration acquired in S**403**.

(3) The CPU **65** determines whether or not each of the observing schedules tentatively set in (2) overlaps with previously registered observing schedules. If a tentatively set observing schedule overlaps with previously registered observing schedules, the CPU **65** determines that time-lapse observing is impossible with the tentatively set observing schedule. If, on the other hand, any of the tentatively set observing schedules does not overlap with previously registered observing schedules, the CPU **65** determines that time-lapse observing is possible with the tentatively set observing schedule and extracts the tentatively set observing schedule as a registrable time zone of the time-lapse observing.

(4) The CPU **65** changes the start time of the time-lapse observing and repeats the operations of (2) and (3). The CPU **65** thus determines whether or not time-lapse observing of the specified incubation container **30** is possible in the idle-time of (1).

Step **406**: The CPU **65** determines whether or not it succeeded in extracting a registrable time zone of the time-lapse observing in S**405**. If the above-mentioned condition is satisfied (the case of YES), the CPU proceeds to S**407**. If, on the other hand, the above-mentioned condition is not satisfied (the case of NO), the CPU proceeds to S**413**.

Step **407**: The CPU **65** displays the registrable time zone of the time-lapse observing (S**405**) on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**).

Here an exemplary display of the registrable time zone of S**407** is shown in FIG. **19**. In FIG. **19**, the above-mentioned registrable time zone is listed on the right-hand side of the screen. In this occasion, the CPU **65** displays the registrable time zone, based on the first-time time-lapse observing. In other words, a time zone in which the previously registered observing schedule does not exist is displayed as an unregistrable time zone on the display screen of FIG. **19**, if observing schedules overlap by executing time-lapse observing starting from that time zone. The CPU **65** then preliminarily disables, on the display screen of FIG. **19**, registration of observing schedules other than during registrable time zones. In FIG. **19**, registrable time zones of the time-lapse observing are shown as blank fields, whereas time zones in which time-lapse observing cannot be registered are shown by hatching.

Then, the user can specify a desired time zone among registrable time zones and register the observing schedule of the time-lapse observing in the second memory **64**. In this occasion, the time zone specified by the user corresponds to the observing schedule of the first-time time-lapse observing. Here, the user's input of the registrable time zone on the display screen is performed via the input button **56***b* of the operation panel **56** (or an input device of the computer **58**).

Step **408**: The CPU **65** determines whether or not an input to register the observing schedule (for example, input via the registration button in FIG. **19**) is accepted with the display screen of S**407** being displayed. If the observing schedule is registered (the case of YES), the CPU **65** proceeds to S**409**. If, on the other hand, no observing schedule is registered (the case of NO), the CPU **65** proceeds to S**410**.

Step **409**: The CPU **65** collectively registers a plurality of observing schedules of the time-lapse observing in the schedule data of the second with memory **64**. Subsequently, the CPU **65** terminates the registration processing of observing schedules of the time-lapse observing.

Step **410**: The CPU **65** determines whether or not a manipulation of changing the condition of the time-lapse observing is accepted with the display screen of S**407** being displayed. If a manipulation of changing the condition of the time-lapse observing is executed (the case of YES), the CPU **65** returns to S**404** and repeats the above-mentioned operation. If, on the other hand, no manipulation of changing the condition of the time-lapse observing is executed (the case of NO), the CPU **65** proceeds to S**411**.

Step **411**: The CPU **65** determines whether or not an input to reset the imaging condition (for example, input via the change imaging condition button in FIG. **19**) is accepted with the display screen of S**407** being displayed. If there is an input to reset the imaging condition (the case of YES), the CPU **65** returns to S**402** and repeats the above-mentioned operation. If, on the other hand, there is no input resetting the imaging condition (the case of NO), the CPU **65** proceeds to S**412**.

Step **412**: The CPU **65** determines whether or not an input to terminate the registration (for example, input via END button in FIG. **19**) is accepted with the display screen of S**407** being displayed. If there is an input to terminate the registration (the case of YES), the CPU **65** terminates the registration processing of observing schedules of the time-lapse observing. If, on the other hand, there is no input to terminate the registration (the case of NO), the CPU **65** returns to S**408** and repeats the above-mentioned operation.

Step **413**: The CPU **65** displays a warning (the screen displaying the warning is not shown here) that a registrable time zone cannot be extracted on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). The CPU **65** then returns to S**404** and accepts input of the time-lapse observing condition again.

Here, when displaying the warning in S**413**, the CPU **65** may display a list of the recommended condition of the time-lapse observing for which a registrable time zone can be extracted (interval, number of times, or period of the time-lapse observing). The user can thus easily recognize the condition under which a schedule of the time-lapse observing can be registered, whereby convenience of the incubator improves.

As an example, the CPU **65** sets the number of times (or period) of the time-lapse observing to be smaller than the input value, and acquires a registrable time zone of the time-lapse observing by a similar calculation as that in S**405**. Additionally, as another example, the CPU **65** sets the interval of the time-lapse observing as a value different from the input value, and acquires registrable time zone of the time-lapse observing by a similar calculation as that in S**405**. Then, if a registrable time zone of the time-lapse observing is extracted by the above-mentioned processing, the CPU **65** displays the parameter of the above-mentioned recommended condition of time-lapse observing and the time zone which is registrable under the recommended condition on the monitor **56***a* or the like. Description of the flow chart of FIG. **18** is thus completed.

With the exemplary variation shown in FIG. **18**, the CPU **65** presents a registrable time zone in which time-lapse observing sequence can be executed without overlapping with previously registered observing schedules. Thus, overlap of observing schedules can be preliminarily prevented by the users selecting a schedule of the time-lapse observing from registrable time zones.

Description of Second Embodiment

Operation of the CPU **65** in the processing of registering the observing schedule in the second embodiment will be described below, referring to the flow chart of FIG. **20**. Here, manipulation of registering the observing schedule of the incubation container **30** is executed by the user via the operation panel **56** of the incubator **11** or the computer **58** coupled to the incubator **11**. Since the arrangement of the incubator, the operation of the observing sequence, and the operation when carrying out the incubation container in the second embodiment are common with that of the first embodiment, duplicate description is omitted.

In the example of FIG. **20**, the CPU **65** can execute collective registration of the observing schedule of the time-lapse observing. Here, in the example of FIG. **20**, description is given assuming the case of "newly register observing schedule", for simplicity.

Step **501**: The CPU **65** displays a selection screen letting the user select an incubation container **30** for which an observing schedule is set on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). Here, since the processing in S**501** is common with S**104** of FIG. **11** described in the first embodiment, duplicate description is omitted.

Step **502**: The CPU **65** displays the detail setting screen of imaging condition on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**). Here, since the processing in S**502** is common with S**105** of FIG. **11** described in the first embodiment, duplicate description is omitted.

Step **503**: The CPU **65** calculates the duration of a single incubation observation of the container **30**. Here, since the processing in S**503** is common with S**106** of FIG. **11** described in the first embodiment, duplicate description is omitted.

Step **504**: The CPU **65** displays a screen for accepting the input of start time and condition of the time-lapse observing on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**).

Here, an exemplary display screen in S**504** is shown in FIG. **19**. A list of previously registered observing schedules is displayed on the right-hand side of the screen in FIG. **19**.

In FIG. **19**, previously registered observing schedules are shown by hatching, whereas time zones which can be specified as start time of the time-lapse observing are shown as blank fields. Then, the user can specify a desired time zone among the above-mentioned specifiable time zones, and input the start time of the time-lapse observing for the CPU **65**.

In the display area shown on the left-hand side of the screen of FIG. **19**, interval, number of times, and period of the time-lapse observing can be input as the condition of the time-lapse observing.

The CPU **65** then fixes the condition of the time-lapse observing if (1) the confirmation button (SET) on the screen is pressed with the interval and number of times of the time-lapse observing having been input, or (2) the confirmation button (SET) on the screen is pressed with the interval and period of the time-lapse observing having been input.

Step **505**: The CPU **65** determines whether or not both the start time of the time-lapse observing and the condition of the time-lapse observing have been input, with the display screen of S**504** being displayed. For example, the CPU **65** determines that the start time of the time-lapse observing and the condition of the time-lapse observing have been input if the confirmation button (SET) on the left-hand side of the screen is pressed with the start time of the time-lapse observing having been specified on the display screen of FIG. **19**. If the above-mentioned condition is satisfied (the case of YES), the CPU **65** proceeds to S**506**. If, on the other hand, the above-mentioned condition is not satisfied (the case of NO), the CPU **65** proceeds to S**512**.

Step **506**: Based on the start time specified in S**505**, the CPU **65** tentatively sets a plurality of observing schedules of the incubation container **30**, in accordance with the time interval and number of times (or period) according to the condition (S**505**) of the time-lapse observing. Here, the period of a single observing schedule in the tentative setting corresponds to the observing duration calculated in S**503**.

Step **507**: The CPU **65** determines whether or not any of the observing schedules tentatively set in S**506** overlaps with previously registered observing schedules. If the above-mentioned requirement is satisfied (the case of YES), the CPU **65** proceeds to S**508**. If, on the other hand, the requirement is not satisfied (the case of NO), the CPU **65** proceeds to S**510**.

Step **508**: The CPU **65** displays a warning (the screen displaying the warning is not shown here) that overlap with previously registered observing schedules is occurring on the monitor **56***a* of the operation panel **56** (or a monitor of the computer **58**).

In this occasion the CPU **65** displays, on the monitor **56***a* or the like, detailed information of the previously registered schedule (identification information of the incubation container **30** and time of day of the observing schedule) overlapping with the above-mentioned tentatively set observing schedule. Therefore the user can recognize in a concrete manner with which schedule the overlapping is occurring.

Step **509**: The CPU **65** deletes the observing schedule of the time-lapse observing which has been tentatively set in S**506**, returns to S**504**, and repeats the above-mentioned operation. In this manner, the user can change the condition or start time of the time-lapse observing to avoid overlap of schedules.

Step **510**: The CPU **65** determines whether or not an input to register the observing schedule (for example, input via the registration button in FIG. **19**) is accepted with the display screen of S**504** being displayed. If the above-mentioned requirement is satisfied (the case of YES), the CPU **65** proceeds to S**511**. If, on the other hand, the requirement is not satisfied (the case of NO), the CPU **65** proceeds to S**512**.

Step **511**: The CPU **65** formally registers, collectively into the schedule data of the second memory **64**, the observing schedule of the time-lapse observing tentatively set in S**506**. Subsequently, the CPU **65** terminates the processing of registering the observing schedule of the time-lapse observing.

Step **512**: The CPU **65** determines whether or not a manipulation of changing the condition of the time-lapse observing is accepted with the display screen of S**504** being displayed. If a manipulation of changing the condition of the time-lapse observing is accepted (the case of YES), the CPU **65** returns to S**504** and repeats the above-mentioned operation. If, on the other hand, no manipulation of changing the condition of the time-lapse observing is accepted (the case of NO), the CPU **65** proceeds to S**513**.

Step **513**: The CPU **65** determines whether or not an input to reset the imaging condition (for example, input via the change imaging condition button in FIG. **19**) is accepted with the display screen of S**504** being displayed. If there is an input to reset the imaging condition (the case of YES), the CPU **65** returns to S**502** and repeats the above-mentioned operation. If, on the other hand, there is no input to reset the imaging condition (the case of NO), the CPU **65** proceeds to S**514**.

Step **514**: The CPU **65** determines whether or not input ending the registration (for example, input via END button in FIG. **19**) is accepted with the display screen of S**504** being displayed. If there is an input ending the registration (the case of YES), the CPU **65** terminates the registration processing of the observing schedule of the time-lapse observing. If, on the other hand, there is no input ending the registration (the case of NO), the CPU **65** returns to S**510** and repeats the above-mentioned operation. Description of the flow chart of FIG. **20** is thus completed.

In the second embodiment, the CPU **65** determines whether or not the tentatively set schedule of the time-lapse observing overlaps with previously registered observing schedules. Then, if an overlap between the both schedules occurs, the CPU **65** warns the user. Therefore, in the second embodiment, overlap of observing schedules can be preliminarily prevented when collectively registering the observing schedules of the time-lapse observing.

Supplementary Notes on Embodiments

(1) Arrangement of respective components of the incubator **11** of the present invention is not limited to the above-mentioned embodiment. For example, the present invention can also be applied to a multi-gas incubator which can regulate, in addition to carbon dioxide concentration, at least either oxygen concentration or nitrogen concentration. Additionally, with the present invention, humidity may be regulated using a humidifying plate which reserves humidifying water and a temperature regulating device which controls water temperature of the humidifying plate. Furthermore, the temperature regulating device **21** in the above-mentioned embodiments may be replaced by a known arrangement such as a combination of a heater unit and a refrigerant recycling system, for example (all of which not shown).

(2) In the above-mentioned embodiments, value of time of the first and second data, or unit time of the schedule data can be changed as appropriate. Additionally, in the above-mentioned embodiments, although the carrying period of the first data is treated as a single value, a plurality of values may be registered in the first memory **63** as the carrying period of the first data, for example, the carrying period may be changed according to the position on the stocker **25**.

(3) In the above-mentioned embodiments, the warning means of the incubator **11** to the user may be replaced by voice output such as a buzzer (not shown), for example.

(4) In an exemplary variation of the first embodiment shown in FIG. **18**, if a registrable time zone of the time-lapse observing cannot be extracted (the case of NO of S**406**), the CPU **65** may eliminate the overlap with previously registered observing schedules by shifting the time zone in which overlap is occurring among the observing schedules of the time-lapse observing.

(5) In the above-mentioned second embodiment, if a tentatively set observing schedule overlaps with previously registered observing schedules (the case of YES of S**507**), the CPU **65** may eliminate the overlap with previously registered observing schedules by shifting the time zone of the tentatively set observing schedule.

(6) When displaying the warning in S**508** of the above-mentioned second embodiment, the CPU **65** may list the recommended condition of the time-lapse observing (start time of the time-lapse observing, interval of the time-lapse observing, number of times or period of the time-lapse observing).

For example, the CPU **65** fixes either the condition of the time-lapse observing (interval, number of times) or the start time of the time-lapse observing, and generates the tentatively set observing schedule by changing other parameters. The CPU **65** determines the tentatively set observing schedule to be a recommended condition if it does not overlap with previously registered observing schedules, and displays respective parameters on the monitor **56***a* or the like. Here, it may be arranged such that the CPU **65** automatically executes calculation of the recommended condition when some of the parameters (for example, with either the start time or the condition of the time-lapse observing (interval, number of times, etc.) specified) are input in the display screen of S**504**.

The many features and advantages of the embodiments are apparent from the detailed specification and, thus, it is intended by the appended claims to cover all such features and advantages of the embodiments that fall within the true spirit and scope thereof. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the inventive embodiments to the exact construction and operation illustrated and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope thereof.

What is claimed is:

1. An incubator comprising:

a temperature-controlled room that has a storage section configured to house a plurality of incubation containers, and configured to maintain an interior of the temperature-controlled room to a predefined environment condition;

an imaging section configured to capture images of a condition of samples within an incubation container in the temperature-controlled room;

a carrying mechanism configured to move the incubation container between the storage section and the imaging section;

a controlling section configured to control the imaging section and the carrying mechanism to automatically execute an observation sequence of the incubation container;

a first memory that stores first data indicating a carrying period of the incubation container by the carrying mechanism, and second data indicating an imaging duration of the imaging section;

a second memory that stores schedule data including a plurality of observation schedules, each of the observation schedules including a start time and an observation duration of the observation sequence in association with one of the incubation containers;

an input section configured to accept, from a user, a first input selection of an incubation container, and a second input selection of an imaging condition;

a controller executing a program stored in memory, the program performing the steps of:

calculating an observation duration of the selected incubation container based on the first data and the second data according to the selected imaging condition;

extracting, based on the stored schedule data and the calculated observation duration, a registrable time zone, the registrable time zone being a time zone in which the observation sequence of the specified incubation container can be executed without overlapping with the previously stored plurality of observation schedules; and

outputting to a display the registrable time zone.

2. The incubator according to claim 1, wherein the program further performs the step of registering, based on a user's input, one of the observation schedules of the specified incubation container into the stored schedule data, and disables registration of the one of the observation schedules other than during the registrable time zone.

3. The incubator according to claim 2, wherein the program further performs the step of:

recalculating the observation duration of the specified incubation container if there is an input changing the imaging condition after registration of one of the observation schedules, and

outputting a notification to warn the user if overlap of the observation schedules occurs due to increase of the observation duration.

4. The incubator according to claim 1, wherein

the carrying mechanism carries the incubation container out from the temperature-controlled room, according to the user's input, and

the program further includes the step of while the observation sequence of the incubation container to be carried out is being executed, outputting a notification to warn the user before carrying out is executed.

5. The incubator according to claim 1, wherein the program further includes the step of outputting to a display a registration status of one of the observation schedules with regard to any of the incubation containers, based on the stored schedule data.

6. The incubator according to claim 1, wherein the program further includes the step of receiving the first input selection and the second input selection from an external computer, and transmitting to a display of the external computer the registrable time zone.

7. The incubator according to claim 1, wherein

the input section further accepts a third input defining a condition of a time-lapse observation of the specified incubation container, and

the program further includes the steps of:

setting the plurality of observation schedules of the specified incubation containers respectively having different observation times, according to the condition of the time-lapse observation, and

extracting the registrable time zone in which each of the observation schedules of the time-lapse observation can be executed without overlapping with the observation schedules being previously registered.

8. The incubator according to claim 7, wherein the program further includes the step of outputting to the display, as the registrable time zone in the time-lapse observation, a first-time time zone of the time-lapse observation.

9. The incubator according to claim 7, wherein the program further includes the step of outputting to the display at least one of a warning and a presentation of the condition of the time-lapse observation for which the registrable time zone can be extracted, when the registrable time zone cannot be extracted.

10. The incubator according to claim 7, wherein the program further includes the step of shifting one of the observation schedules of the time-lapse observation, when the registrable time zone cannot be extracted.

11. A schedule management method for an incubator, wherein

the incubator comprises:

a temperature-controlled room that has a storage section configured to house a plurality of incubation containers, and configured to maintain an interior of the temperature-controlled room to a predefined environment condition;

an imaging section configured to capture images of a condition of samples within one of the incubation containers in the temperature-controlled room;

a carrying mechanism configured to move one of the incubation containers between the storage section and the imaging section;

a controlling section configured to control the imaging section and the carrying mechanism to automatically execute an observation sequence of one of the incubation containers;

a first memory that stores first data indicating a carrying period of the incubation container by the carrying mechanism, and second data indicating an imaging duration of the imaging section;

a second memory that stores schedule data including plurality of observation schedules, each of the observation schedules including a start time and an observation duration of the observation sequence in association with one of the incubation container; and

an input section configured to accept input from a user, and

the method comprises:

accepting a first input selection of an incubation container, and a second input selection of an imaging condition;

calculating an observation duration of the selected incubation container based on the first data and the second data according to the selected imaging condition;

extracting based on the stored schedule data and the calculated observation duration, a registrable time zone, the registrable time zone being a time zone in which the observation sequence of the selected incubation container can be executed without overlapping with the previously stored plurality of observation schedules; and

outputting to a display the registrable time zone.

12. The schedule management method according to claim 11, further comprising:

receiving the first input and the second input from a computer coupled to the incubator, and

transmitting to a display of the coupled computer the registrable time zone.

13. A non-transitory computer readable storage medium storing a program for an incubator, wherein

the incubator comprises:

a temperature-controlled room that has a storage section configured to house a plurality of incubation containers, and configured to maintain an interior of the temperature-controlled room to a predefined environment condition;

an imaging section configured to capture images of a condition of samples within one of the incubation containers in the temperature-controlled room;

a carrying mechanism configured to move one of the incubation containers between the storage section and the imaging section;

a controlling section configured to control the imaging section and the carrying mechanism to automatically execute an observation sequence of one of the incubation containers;

a first memory that stores first data indicating to a carrying period of one of the incubation containers by the carrying mechanism, and second data with indicating the imaging duration of the imaging section;

a second memory that stores schedule data including plurality of observation schedules, each of the observation schedules including a start time and an observation duration of the observation sequence in association with one of the incubation containers; and

an input section configured to accept input from a user, and

the computer readable storage medium storing the program causes the controlling section to execute:

a first step of accepting a first input selection of an incubation container, and a second input selection of an imaging condition;

a second step of calculating an observation duration of the selected incubation container based on the first data and the second data according to the selected imaging condition;

a third step of extracting, based on the stored schedule data and the calculated observation duration, a registrable time zone, the registrable time zone being a time zone in which the observation sequence of the selected incubation container can be executed without overlapping with the previously stored plurality of observation schedules; and

a fourth step of outputting to a display the registrable time zone.

14. The non-transitory computer readable storage medium storing the program according to claim **13**, wherein the program further comprises:

receiving the first input and the second input from a computer coupled to the incubator, and

transmitting to a display of the coupled computer the registrable time zone.

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